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SHE puts up her hair with a plastic comb; surveys herself in a plastic mirror; a plastic bracelet on her wrist; bright plastic buttons ornament her dress. She is one of a generation rapidly becoming plastics conscious. She realises that war-time demands have curtailed the output of the charming plastic novelties, trinkets and household devices that once captivated her, and sometimes she wonders what we have in store for the future . . . What have we? . . . We have years of experience of plastics research and development, an up-to-the-minute knowledge of the new trends and methods speeded up by war-production and a first rate range of plastics products already well-established. If you have plans that include the use of plastics we shall be pleased to advise you.

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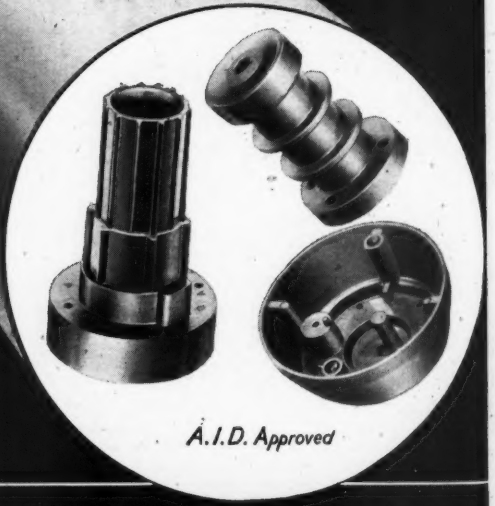

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Alice in Plasticland—No. 6

Alice is bewildered

It still looks a long way from here to plastics, thought Alice, close up to one of the benches in the laboratory, and confronted with test tubes, bottles and scales, at close quarters. Something very important happens here but I can't quite grasp it. Still, where there's a laboratory there must be a chemist. She looked round for some one to explain what she saw to her and didn't have very far to look. A chemist was approaching. Alice prepared to pepper him with her plastic perplexities.

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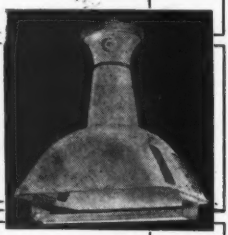

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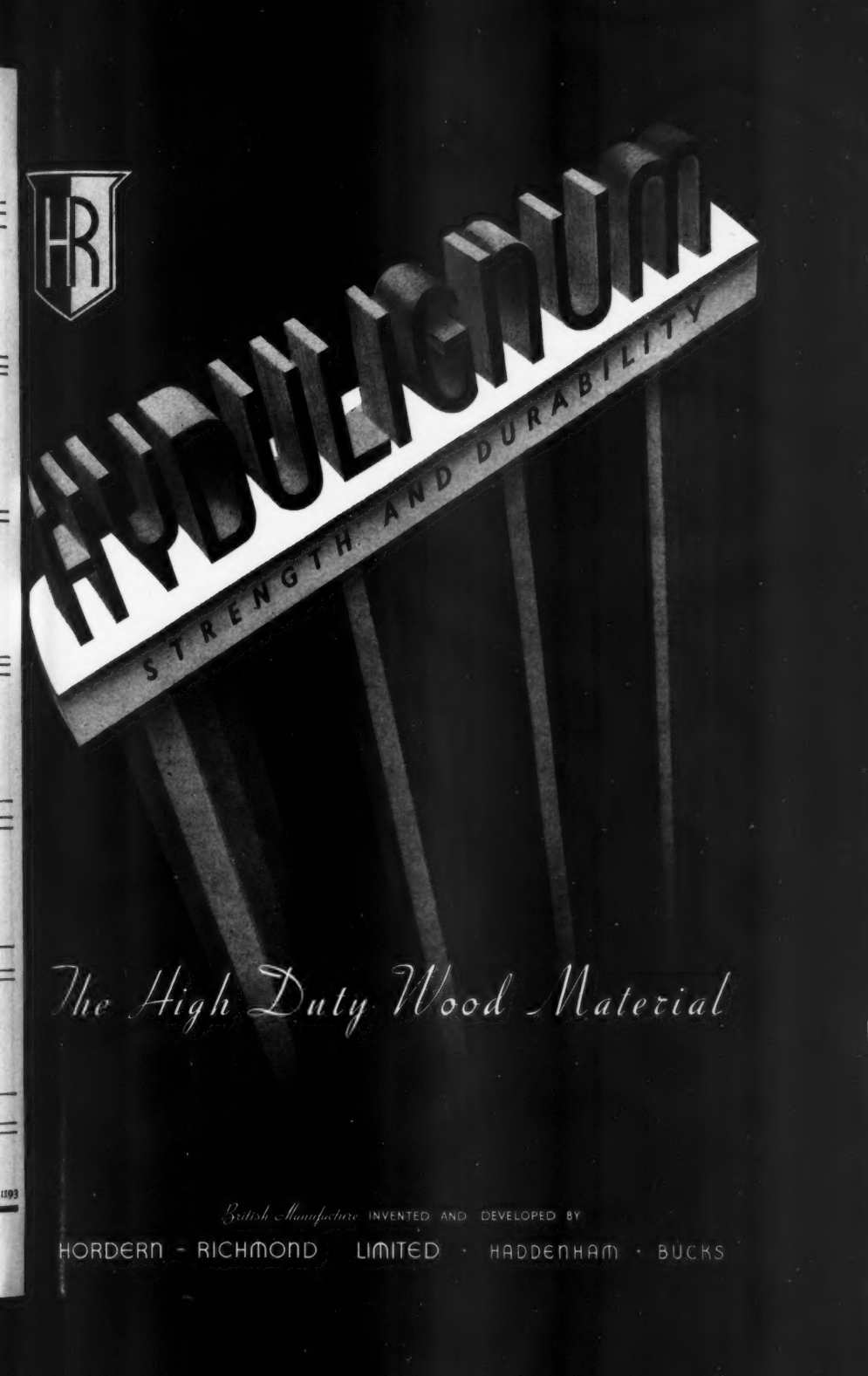
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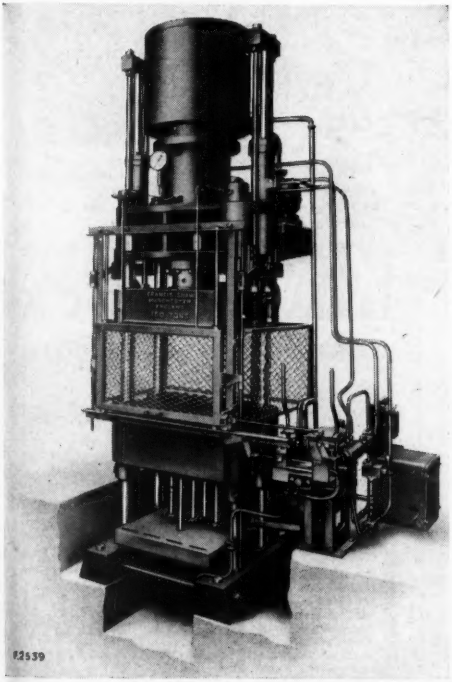

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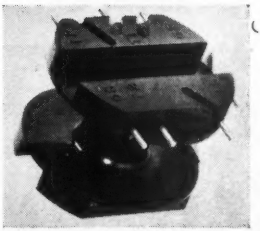
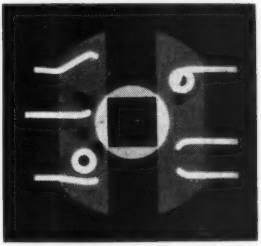


Photograph of moulded component—by courtesy of British Industrial Plastics Ltd.



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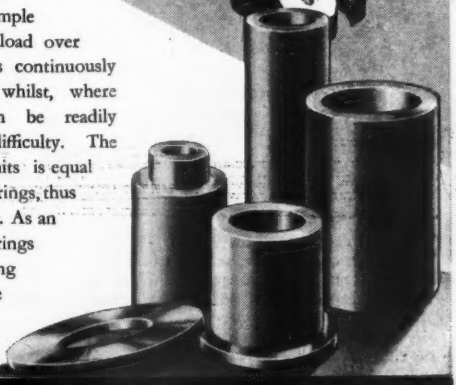

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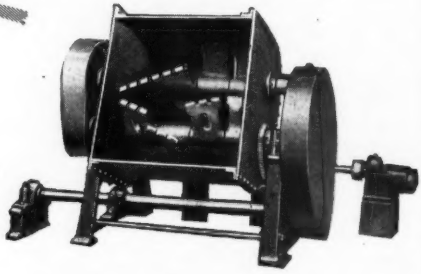

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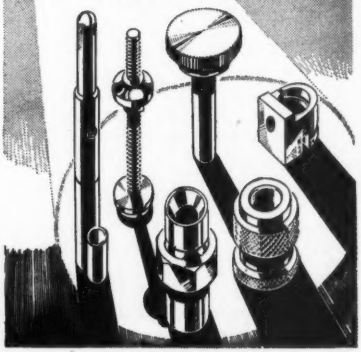

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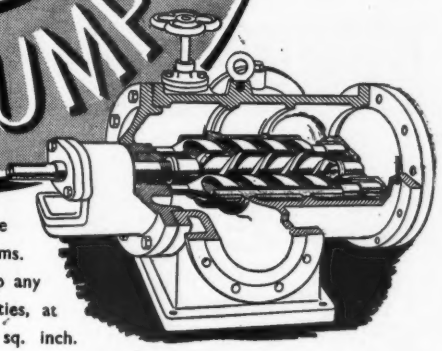

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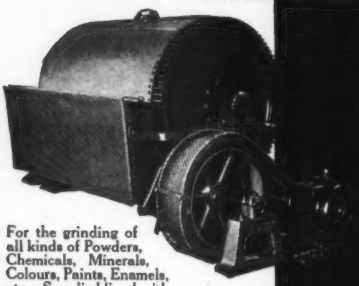

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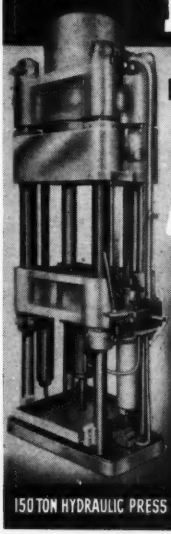

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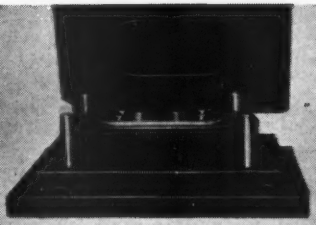

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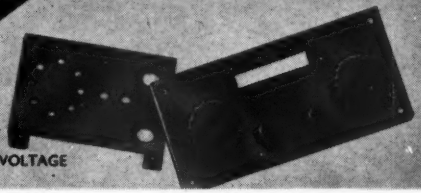

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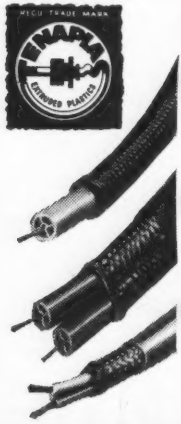

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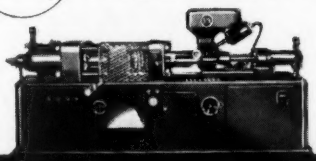

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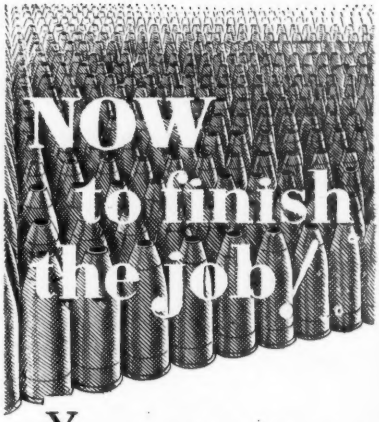

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Vol. VIII. No. 88 SEPTEMBER, 1944

Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

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NOTICES

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SAVE PAPER

More than ever is paper waste required for our war industries. Waste paper makes munitions in a hundred forms—from shell cases to aeroplane parts.

The fact that goods made of raw materials in short supply because of war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

EDITORIALS

Fair Play

DURING the past five years we have received in this office a more or less constant stream of industrialists and merchants who, in one way or another, have wanted to use or sell plastics. Those of them who wish to deal in goods which cannot claim some sort of priority have had no chance whatsoever to get acquainted with what our industry can do other than by the occasional glimpse of a photograph in a technical journal or from the "blurbs" in some of our more excitable daily papers which have promised them a strange but definite paradise on earth.

To-day the tempo is stepped up, and more and more frequent do the questions pour in. How are we preparing for post-war developments?

Last week there came into this office a representative of a well-known South African concern desirous of preparing for post-war business, very anxious to use plastic containers for cosmetics and similarly packed goods and wanted to know what British goods are available. He pointed out that the firm was especially keen on buying British, but that American salesmen were already in South Africa offering many beautiful samples of the very types they require.

We had no need to remind him that this country was in the firing line, that 99.9 per cent. of manufactures were direct war products, that all our plastic factories were chock-a-block full of orders on war jobs and that no other orders were permissible. He knew all that, but put the cold facts before us—the American salesmen are in South Africa and elsewhere, and what are we doing about it?

It's a serious situation, obviously. Our Export Group exists only in name, our raw materials are limited in quantity, many of our factories have been bombed, and with our comparatively small population and terrific drain on our manpower we are at an enormous disadvantage compared with America, which has felt the impact of war neither so long nor so directly. Her pool of manpower and raw material allows her, in spite of her immense help in producing war material and armies, an important surplus which can be diverted to goods of which we can only dream. America cannot be blamed for such a situation.

Sometimes when we think of these things and of the apparently strange behaviour of the Governmental Licensing Department which deals with exports, we wonder whether some of our politicians and statesmen have not stumbled somewhere.

We must finish the war first. That is our paramount duty. But our life's blood in peace-time depends largely on exporting our manufactured products, and we must be given the chances of selling them on equal terms with other nations.

Production Figures and Costs

IN all our arguments regarding the future trend of the plastics industry there is always the recurrent problem of increased production and lower cost.

The plastics industry in pre-war days was in total weight output one of the smaller industries and world production was of the order of 150,000 to 200,000 tons. Whence will come the much larger quantities which—and it takes no great prophet to point out the coming demand—will surely, be required.

What, too, of raw material cost, which, while we made specialities restricted to certain industries and while ingenuity of

design, elimination of manufacturing operations, beauty and so on did much to discount disparity in cost, will have to fight vigorously in wider fields against older materials which have also been improved and cheapened during the war years?

Production figures of plastics in this country before the war were put at roughly 30,000-40,000 tons and world figures at about 200,000 tons. How much will be needed after the war is anybody's guess, but it is equally certain that a great expansion has already taken place in all types, thermosetting and thermoplastic, with special emphasis on the latter.

Of all manufactures, the most startling increase has taken place in polystyrene, not, it is true, for ordinary plastics usage, but for co-polymerization for synthetic rubber production in the U.S.A. In this connection an interesting story has been told by Dr. J. J. Pyle in a paper presented to the American Society of the Plastics Industry. He states that while the quantity of polystyrene used was surprisingly small before the war, nearly 180,000 tons of the monomer will be manufactured in America this year for synthetic rubber alone, an amount which approaches that of the total world production of all plastics some six or seven years ago. He also adds that the price of this 93-95 per cent. grade of styrene can be brought down to 8-11 cents per lb., which brings polystyrene down to a possible 22 cents per lb. If such quantities are released at this low price (and it has been presumed that synthetic rubber will be severely curtailed) it seems certain that this plastic, with its excellent properties, will find a much wider use than it does at present, where cost has hitherto prohibited its adoption.

Polyvinyl chloride, too, has been produced in much larger quantities. Dr. Pyle gives the 1940 American output (including polyvinyl acetate and acetals) as 8,000 tons against a calculated 48,000 tons for 1944. Unofficial figures give the cost of vinyl chloride monomer as 6-8 cents per lb., and those of us who remember seeing polyvinyl chloride toys in Germany in 1939 are wondering whether there is any limit to its use at, say, 16-20 cents per lb.

The acrylate production increased from 8,500 tons in 1941 to 22,000 tons (estimated) in 1944. Here, no doubt, the bulk has been used in aircraft, and since, also, the production of the monomer is more complicated than either styrene or vinyl chloride, it is difficult to prophesy either a big diminution in price or a much wider expansion in use.

One thing is clear. We can increase our raw material supplies for plastics in war-time without too serious a dislocation. But we in this country must remember that our phenols have been secured for the plastics industry by restricting others: dyestuffs production, agriculture disinfection, etc., which in peace-time will demand access to this supply. It is obvious the total phenols must be greatly increased. Likewise with our benzole and alcohol supplies. The problem of increasing the former is of first importance and must be coupled with the job of teaching the Chancellor of the Exchequer that industry should not be sabotaged by making it pay the same tax as the joy-rider does for his petrol. Pre-war industrial alcohol was fairly cheap, thank goodness, but could be cheaper. Larger quantities would be required, and it is disturbing to hear that much of our alcohol for certain plastics is being imported from America!

If our readers wish to read a good story regarding our raw materials, they should turn to Mr. Kenneth Chance's recent Chance Memorial Lecture given before the Society of Chemical Industry on June 28 last.

Books Received

"Plastics Molds," by G. B. Thayer; American Industrial Publishers. "Plastics for Production," by P. I. Smith; Chapman and Hall. "Gravity Die Casting Technique," by G. W. Lowe; Hutchinsons. Reviews of these books will be published in a forthcoming issue.

A Urea Formaldehyde Glue in Powder Form

By E. E. HALLS

UREA adhesives are extensively employed in industry, but perhaps the major application concerns timber. In this direction, it has proved itself eminently suitable for securing the laminæ of plywood as well as for cementing wood veneers and paper facings to sheet and board in general. Pressing between hot platten is the usual procedure, although in some instances the jointing is performed at ordinary room temperatures. Thus the technique follows closely that employed when the orthodox liquid vegetable or animal glues are utilized. Actual conditions depend, of course, upon the formulation of the urea formaldehyde glue, but a typical set of conditions would be a press temperature of 90 to 100 degrees C., a pressure of 28 lb./sq. in. or more, depending on the overall thickness of the board being treated, and a time period of from 5 to 15 mins., according to the number of joints and the depth of the innermost junction from the surface of the sheet.

The urea formaldehyde glues may be prepared on site from the basic ingredients by the user himself, but more generally they are purchased as proprietary articles and used in accordance with the supplier's instructions. A urea formaldehyde glue is usually supplied as two separate components, each liquid. One of them is a syrup consisting of the urea formaldehyde combination in aqueous solution. The solution is viscous and highly concentrated. The second liquid is the "hardener," comprising a water solution of the chemicals necessary to promote the conversion of the urea formaldehyde to its insoluble, infusible form. The two are intimately mixed in specified proportions immediately prior to use. Actual proportions are dependent upon the precise make-up of the two products. Again, the composition of the hardener or condensation agent will vary according to whether a hot or cold process is to be employed, as well as with the rate of hardening required, that is, extra rapid, rapid or slow. The hardener may thus range from solutions of hydrochloric acid, through ammonium chloride to ammonia, with excess of acid or excess of alkali (ammonia) according to the results desired. Tables Nos. 1 and 2 show some analytical test results on a commercial product to give some idea of the scope covered. Table No. 1 refers to the urea formaldehyde syrup and No. 2 to the hardeners. In making up the glue for use, 10 parts by weight of the urea syrup are mixed with one part of hardener. The mixture may be diluted or filled with appropriate grades of flour or starch, e.g., rye flour, and diluted with water to a suitable consistency if desired. It will be noted that the syrup is highly concentrated, much more so than the "liquid"

Table 1.—Analytical Characteristics of Urea-formaldehyde Liquid Glue.

Nature. Viscous syrup-like liquid	
Composition per cent. by weight:—	
Urea-formaldehyde reaction product	75.0
Water	25.0
	100·0

Table 2.—Analytical Characteristics of Urea-formaldehyde Glue Hardeners.

Sample No.	1 Cold hardener	2 Hot hardener
Nature	Aqueous liquid	Aqueous liquid
Composition per cent. by weight:—		
Ammonium chloride	2.34	1.07
Ammonia	Nil	0.88
Water..	97.66	98.05
	100.00	100.00

Table 3—Laboratory Characteristics of Natural "Liquid" Glues for Woodwork.

Sample No.	1	2
Nature	Stiff Jelly	Stiff Jelly
Composition per cent. by weight:—		
Gelatine	31.0	27.3
Ash on incineration ..	1.1	1.0
Organic matter other than gelatine	1.3	0.9
Water	66.6	70.8
	100.0	100.0

Note.—The ash was alkaline, chiefly lime containing traces only of phosphates and chlorides.

glues generally employed. Characteristics of two of these marketed in jelly form especially for woodwork are shown in Table 3. They are both excellent grades of their type. The hardeners, it will be noted, are of similar order with respect to total concentration, but that the cold hardener is much higher with respect to the acid radicle (chloride ion). Functioning in the cold, and rapidity of hardening, is due to this feature. The stability or keeping-time of the cold hardener mixture is about half an hour at 20 degrees C., and of the hot hardener mixture from four to four and a half hours. The stability of the hot hardener mixture over a range of temperatures is given in Fig. 1. It will be seen that there is ample margin for day-to-day working. The dotted portion of the curve is extrapolated to the normal working temperature and time, that is, 90 to 100 degrees C. with 4 mins. plus 1 min. per mm. of thickness to the innermost junction, pressure 28 lb./sq. in. The cold hardened mixture requires from 3 to 8 hrs.

It will be seen that the use of urea-formaldehyde glues, whether of hot or cold variety, entails the user mixing two ingredients in specified weighed proportions. Admittedly, there is nothing very arduous in this, but it has its drawbacks. For large quantity work and continuous operation, space can be allocated in the shop adjacent to the glueing position. Proper tilting fixtures to aid pouring from the cans, measuring or weighing devices and a suitable mixer can be provided, commensurate to the needs of the job. With continuous operations, intermediate batch making suffices and can be controlled for the avoidance of any excess, and therefore no wastage occurs. With day-shift working, very little loss occurs if operating is properly planned. Further, by means of a neat layout for the mixing and methodical working, no mistakes need occur, and the mixing area can be maintained quite clean. On the other hand, when work is very intermittent and miscellaneous, or a variety of applications concerned but dispersed over several portions of the factory, more attention and stricter control has to be given to the mixing. Otherwise, errors in mixing may arise, with resulting adhesion troubles, and excess of mixture made that aggregating over a period may prove an appreciable loss.

Actually there are ready-mixed urea adhesives in powder form on the market, and these have quite good stability properties for withstanding storage conditions for limited periods. It is considered, however, that they still leave something to be desired in this direction, and more

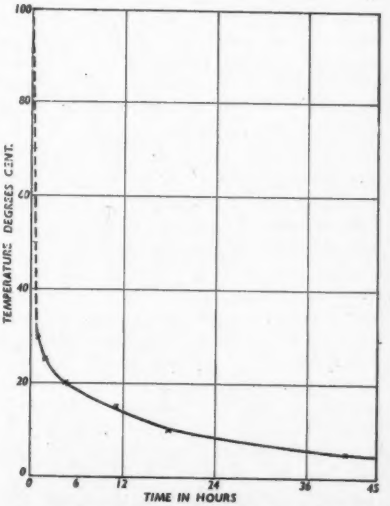


Fig. 1.—Stability of liquid urea-formaldehyde glue with "hot" hardener (10 parts glue syrup and one part hardener by weight).

development work is required before they are perfected.

With the liquid urea formaldehyde glues, it is essential, with the types of formulation devised to date, that the two ingredients be mixed immediately prior to use. This is evident from the stability times already given. In this connection, patent specification No. 551,401, dated 22.2.23, is of fundamental interest. This follows an American invention and patent, credited to Wm. Cockrum Dearing. It relates to a stable dry mixture of urea formaldehyde adhesive and hardener which can be used as an adhesive or coating compound by the addition of water at the time of use. If the preparation can be exploited commercially, and can give adhesive qualities and strength values of the liquid urea formaldehyde glues, it is the type of preparation that is sought to overcome the objections noted above. Obviously, it has to be packed so that it can be kept dry in transport or storage, the ingredients must be stable chemically, non-volatile, must not separate by sedimentation in transit or handling, and the material constituting the package must be without detrimental effect upon the contents. The solid glue still requires a mixing operation, that is, with water, but this should prove simple and straightforward, and still cannot be made up in excess or for excessive periods.

The patent refers to the generally recognized merits of urea formaldehyde glues and their formulation. It points out that the salient features of aqueous urea formaldehyde solutions as an adhesive or coating composition is the fact that the reaction product can be caused to become insoluble after application, and in this way can be made to provide an adhesive waterproof bond or superficial coating. The aqueous urea formaldehyde solutions possess the unique advantage over other resin formers in the speed with which this transformation from soluble to insoluble can be achieved after application, as well as with respect to the simplicity with which it is affected. Further, it can be brought about at ordinary temperatures, therefore extensive hot presses, which may be large, e.g., in the plywood industry, are not essential, although they may be required for greater speed of operating. The patent mentions ammonium chloride and ammonium thiocyanate as the ingredients of the usual hardeners, and ammonium sulphate, phosphate and oxalate as alternatives. It also mentions that the urea formaldehyde reaction product for glues is sold commercially as a solid or as a solution, but that in both cases the hardener solution has to be added by the user at the time of using, claiming this to have been a severe handicap in the development of the urea formaldehyde adhesive industry, not only for industrial applications, but also in domestic exploitations, because of the essential need for accuracy of measuring out the proportions of the two components, facilities for which do not exist in small factories and certainly not in the home.

Endeavours to mix the dry urea formaldehyde reaction product with dry ammonium chloride have not met with success because hardening rapidly proceeds even in the dry state, and the bulk soon becomes valueless. Dearing's patent, however, claims a hardener and a solid mixture that is successful, and which forms a self-hardening adhesive merely upon the addition of water. His claims are summarized below:—

(1) A stable dry mixture of binder and hardening agent comprising a hardenable water-soluble urea formaldehyde reaction product mixed with an ammonium salt of a non-volatile acid such that a 1 per cent. aqueous solution of the acid has a pH value not greater than about 4, the mixture being adaptable to the production of a self-hardening composition upon the addition of water.

(2) A stable dry mixture as in (1) in which ammonium sulphate is the ammonium salt meeting the pH stipulation.

(3) A stable dry mixture as in (1) including a pigment, for use as a water paint.

(4) A stable dry mixture as in (3)

wherein the pigment is dispersed in the hardenable water soluble urea formaldehyde reaction product.

(5) A stable dry mixture as in (4) in which the ammonium salt is ammonium sulphate.

It is claimed that the dry mixture containing the specified type of hardening agent is as stable over long periods of time as the dry urea formaldehyde reaction product by itself. The desired rate of hardening of the final aqueous solution is achieved by incorporating the relevant quantity of ammonium salt in the dry mixture. Such mixtures can be marketed for domestic use because of the ease with which they can be used, and the fact that any desired quantity of water solution can be prepared. It is assumed that mixing and packing are such that sedimentation or separation of ingredients does not occur. For coating compositions such as paints or distempers, suitable pigment or pigments can be incorporated in the mixture. They may be mixed in with the solid urea formaldehyde reaction product by grinding, for example, in a ball mill. Preferably, however, they are dispersed in the aqueous solution of the reaction product before the latter is solidified. Evaporation of the mixture can then proceed in one of the orthodox methods, using a spray-drier, vacuum drier, etc. Again, a non-volatile, water-soluble, organic compound may be included in the mixture to serve as a plasticizer in the final applied coating. Such a material is ethylene glycol. A ball mill, roller mill, or colloid mill can be used to assist mixing prior to drying.

The quantity of pigment incorporated in the mixture can be selected to obtain either matt or glossy coatings. Equal parts by weight of pigment and of urea formaldehyde reaction product are mentioned as resulting in glossy coatings, and higher proportions of filler are suggested for flat finishes.

The patent stresses that the acid, of which the ammonium salt is employed as hardening agent in dry urea formaldehyde adhesive mixtures, must be one that is non-volatile and of which a 1 per cent. aqueous solution gives a pH value not greater than about 4. A weaker acid (that is pH value greater than 4) cannot be employed because its ammonium salt will not effect proper hardening of the bond or coating.

Again, the ammonium salt of a volatile acid of similar strength cannot be used because hardening of the urea formaldehyde reaction product occurs in the solid mixture, and the product is thus not stable and gradually loses its water solubility. Ammonium chloride, ammonium thiocyanate and ammonium nitrate fall in this category and are unsuitable.

The patent defines the term " dry mixture " as one that is dry to the touch. The product obtained by spray drying a solution of the urea formaldehyde reaction product may contain from 1 to 2 per cent of water; it is dry to the touch and is satisfactory. Actually, the quantity of water in the mixture may be increased until a gummy mass is obtained without reducing stability to an appreciable degree. Such gummy products are not, however, considered suitable for the market. They are not very easy to dissolve in water, not so favourable as a granular or powdered mixture, which dissolves easily.

In the mixing of the dry reaction product with the dry ammonium salt, the former may be powdered or granular product and the latter in the form of fine crystals. In the case of the dry mixtures for water paints, the pigment-reaction product combination can be prepared in granular or powder form and then mixed with the ammonium salt in the finely crystalline state. Pulverizing, as by ball mill, is not advocated after the ammonium salt has been added to the reaction product or to the pigment-reaction product mixture.

The patent explains the mode of functioning of the mixture, after dissolving in water, to be due to the ammonium salt becoming gradually more acid by virtue of extraction of formaldehyde from the urea formaldehyde reaction product. This produces the hexamethylene-tetramine salt of the same acid, which is much more

acid than the original ammonium salt. The mixture becomes more and more acid, and in consequence, the hardening of the urea formaldehyde reaction product accelerates after it has been applied, becoming insoluble in a relatively short period of time.

The quantity of ammonium salt employed is that required to give hardening with the desired rapidity. The quality of urea formaldehyde reaction product is that produced by reaction in aqueous solution; if the reaction is carried too far, subsequent dilution with water causes precipitation, and this is an undesirable feature. The reaction product should be such that, when a quantity of water is applied to it such that it gives a composition equivalent to the consistency required for the method by which to be finally applied (e.g., brush, roller, or spray), it does not precipitate.

The preparation of the water soluble urea formaldehyde reaction product is exemplied as follows:—

One molecule of urea is added to a 37 per cent. aqueous solution of formaldehyde containing two molecules of formaldehyde that has been brought to a pH value of 4.5 to 5.5 by means of sodium hydroxide. The solution is heated under reflux gently until the reaction is carried to a suitable stage (about 1 hr.). The solution is neutralized and then evaporated (e.g. spray or vacuum drum drier) to produce a solid product.

The urea formaldehyde reaction product should be prepared in a substantially neutral condition, e.g., by neutralization of the initial aqueous solution of reaction product prior to evaporation. A dry urea formaldehyde reaction product that is acid is stated to be unstable even without hardener added.

Examples of solid adhesives are given, as follows, and in them the ammonium sulphate may be replaced by ammonium dihydrogen phosphate, diammonium hydrogen phosphate, or ammonium oxalate containing two molecules of water of crystallization. All parts are given by weight.

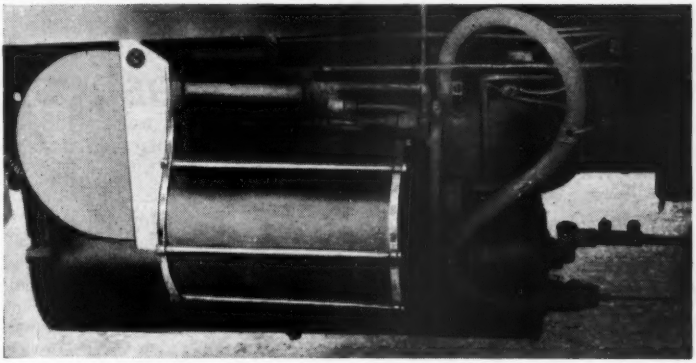
Example 1

A spray dried urea formaldehyde reaction product is prepared as above. With 100 parts are mixed one part of dry ammonium sulphate. Fillers or extenders may be added if desired. Water is added to the desired consistency to suit application, and an adhesive or impregnating medium of self-hardening type is procured. Assembled components glued with this adhesive may be held at ordinary temperatures to harden, while plywood panels and similar articles may be placed under pressure. To increase the rate of hardening a heated press may be used or the panels can be clamped and stored at elevated temperature.

Example 2

An aqueous solution containing 100 parts of the urea formaldehyde reaction product is prepared as before described, and 100 parts of titanium oxide pigment is dispersed in the solution using a roller mill. One part of ethylene glycol is added as plasticizer to the mixture dried in a spray drier. To 200 parts of the spray dried product, one part of dry ammonium sulphate is added and mixed. With this mixture, water can be incorporated to form a water paint to suit brushing, spraying, etc. The resulting paint is quick drying, being dry to the touch within 1 hr. of application. It is insoluble within a few days and can be washed. It does not dust off and resembles an oil paint.

Dearing's patent is of interest because it is a recent one that covers a very useful product, because it refers specifically to methods of preparing the mixtures claimed, processes and plant used, as well as giving actual formulæ. The reference to pH values as a discriminating factor in choice of suitable acid radicles is very satisfying since in several fields of application of the urea formaldehyde reaction products it is felt that pH measurements can serve as a controlling feature. It will be interesting to see how far these solid adhesive mixtures can be developed and exploited, and if they are able to fulfil the promise of wide success that they appear to offer at first sight.



Above, complete servo system in position on a heavy lorry. Reproduced at the foot of the page is a drawing showing constructional details, plastic components being outlined in black. The unit weighs, in all, only 21 lb.

Servo System Features Plastics

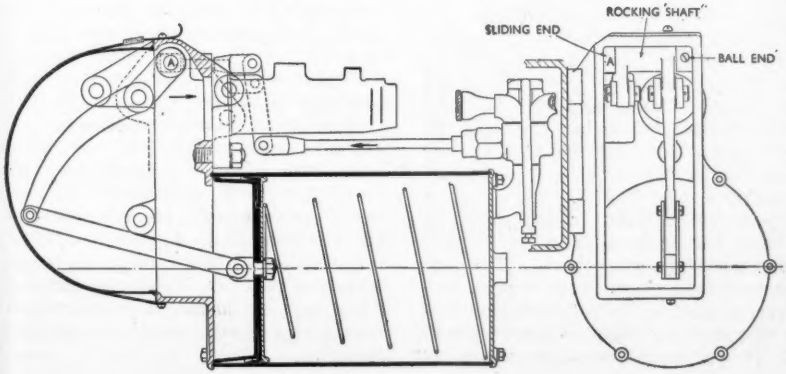
Service Tests Have Demonstrated the Efficacy of a New Valve-operating Mechanism, and of Plastic Components in the Assembly

ON page 194 of our issue for May, 1943, some details were given regarding a plastic vacuum cylinder embodied in a servo-brake system developed by Feeny and Johnson, Ltd., of Wembley.

The plastic cylinder was, at first, used in conjunction with a metal piston fitted with the usual leather washer. Further developments, however, have now resulted in the production of an assembly consisting of not only a plastic cylinder but also a plastic piston, together with a washer fabricated in a soft, wear-resistant rubber-like synthetic; this is illustrated.

This entire plastic assembly, which is shown outlined in black below, now forms part of the complete unit illustrated. Many new features are embodied, and have been made the sub-

(Continued on p. 425)



World's Industry Employs Plastics

GENERAL ENGINEERING

Protection of micrometer barrel against dust and magnifying divisions and figures on the barrel are services simultaneously rendered by a novel device produced by the Stebar Mechanical and Electrical Research Laboratory, Minneapolis; it consists of a cylindrical shell of transparent methylmethacrylate resin. **Fabric-base laminated phenolic plastic** (ASTM Grades, C.Ce, L,Le and Aa) form subject matter of four-page material work sheet in "Machine Design," 1944/16/157. Physical and electrical properties, resistance to corrosion, details for machining and typical mechanical characteristics and applications are tabulated. Machining and forming of Vinylite sheet is comprehensively treated in "The Tool Engineer," 1944/13/86. All machining and forming methods are dealt with, and deviations from common practice are specially illustrated. To protect the surface of thick sheets from scratches and dirt during process it is suggested that masking paper backed with a pressure sensitive adhesive for attaching to the sheet with pressure sensitive tape be used. The importance of temperature control in plastic forming is emphasized. **Compressed wood laminate "Obo-N-Holz"** is being employed by German tool designers for punching dies, according to "Technische Rundschau," Berne, No. 6, 1944. The cutting plate only is steel employed in the form of an overlay $\frac{5}{16}$-in.-$\frac{3}{8}$-in. thick, all other parts being made of pressed wood. The tools are very light and easy to handle, and make possible an overall saving in cost of 85 per cent., with a saving in labour of 33 per cent. **Small grommets of spirally wound laminated acetate film** are manufactured by the Precision Paper Tube Co., 2023, West Charlston Street, Chicago 47, Ill. They are said to provide exceptional insulating properties and to be remarkably tough. They are light in weight and resistant to oil, moisture and climatic changes. One end of the grommet is usually spun over, and various lengths, diameters and wall thicknesses are supplied ("Machinist," 1944/88/144). **Fully cured laminated thermosetting sheet** produced by Panelyte Division of St. Regis Paper Co. can be stamped, bent and drawn similar to sheet metal. For the purpose, moulds of Kirksite (a zinc-base alloy), cast phenolic resin, laminated phenolic resin or any suitable hardwood may be used. Plastic plug gauge has appeared on the market in the U.S.A. The handle moulded, the holding bushes moulded of plastics of different colours: say green for "go" and red for "not go." The handle colour coded, of course, for the type of tolerance applied: superfine, fine, medium, coarse, and the pin gauge itself a plain rod run off most probably from the centreless grinder. The costs of the standard-type tapered pin gauge to the rod may compare for the same limits and surface finish as 10 to 1. But this does not do full justice to the new gauge. say only $\frac{1}{8}$-in. depth has to be gauged, then the life of the new gauge is eight times that of the old, as worn ends can easily be cut off. As contrasted to the traditional all-steel gauge, the new type incorporating plastics is principally to be commended for the fact that it enables much "unnecessary" precision machining to be eliminated. In particular, difficulties entailed in the accurate centering of the variously turned and ground parts of the one-piece metal job in order that concentricity is maintained, are entirely avoided.

AIRCRAFT

Thiokol tape for sealing riveted fuselages, fuel tanks, gun ports and other aircraft assemblies is being produced by Presstite Engineering Co., St. Louis, Mo. The material is supplied in thicknesses from 0.015 in. up to 0.125 in. in bulk, and is available also in the form of slugs designed for use in pressure air guns. In this way any fuel tanks in aircraft can be resealed by the pressure injection method. **Typical fuselage fabricated from plastic bonded plywood** is taken by Hiscocks (" Trans. A.S.M.E. 1944/66/169) to indicate the general procedure followed in building wooden aircraft. A method is described for the fabrication of spare tanks for fighter aeroplanes from plywood. **Battery case of polystyrene** is employed by the Willard Storage Battery Co., Cleveland, for a new and novel design of storage cell. It is stated that a high-voltage type of outstanding electrical capacity is produced less than 1 in. high and weighing in all only 6 oz. The chemical inertness and transparency of the cases is commended, together with the fact that polystyrene is lighter than glass and somewhat stronger than hard rubber. Used also in the batteries as material for separators is Fibrite, which is claimed to prolong life by retarding scaling of active material from the plates during disuse. **Reclaimed synthetic rubber** is now being processed by a new method in the words of the United States Rubber Co. in order to salvage the large amount of scrap accumulating during manufacture. Some 500 tons have already been recovered in this way and a further supply of over 2,500 tons is on hand for further treatment (" Automotive and Aviation Industries," 1944/90/40). **Windows for aircraft and automobiles** are, according to a German source, produced by polyvinyl chloride or acrylic resins over which is sprayed a film of gold, silver, tungsten, etc., to a thickness of about 0.001 mm. The metal layer serves as a high-resistance conductor for a low-tension current, but gives sufficient heat to maintain the surface free of condensation. Presumably films of this thickness are only applied around edges, etc., and the process does not refer to the application of some transparent films.

CHEMICAL

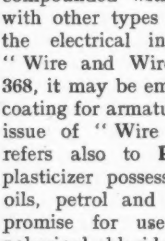
Transport in plants manufacturing explosives and combustibles demands many special features, amongst which tyres of poor electrical insulating power in order to guard against accumulation of static charges may be numbered. United States Rubber Co. is now producing solid tyres of a specially high conductivity for industrial use in these connections. **Flexible mallets** manufactured by the Southwest Manufacturing Co., Santa Anna, California, are now equipped with Pyralin inserts fixed by a thread. These inserts are quickly replaceable. The heads are made of a non-sparking non-magnetic alloy (" Machine Tool Blue Book," 1944/40/351). **Hose assemblies compounded of a rubber-like vinyl plastic** are immune to the action of aromatics in high concentration.

BUILDING

Reeds growing in the Danube delta are, according to information coming from Rumania, to be employed for the construction of artificial board, similar in properties to natural wood. This is to be used for house construction, for which purpose fire and water-resisting qualities are said to be highly desirable.

ELECTRICAL

Duralon, a furane resin, is said to be characterized by lowest water absorption of any organic plastic. In the fully cured state it is insoluble in any solvent or combination of solvents, has high electrical resistivity, is chemically stable and easily worked. Initially, the resin occurs as a heavy, viscous liquid of dark red colour. Curing is by means of mild heat in conjunction with the use of catalysts. The resin obtained is both hard and dense and black in colour, and its properties may be modified in the customary way by the use of various fillers and plasticizers. Duralon is manufactured by U.S. Stoneware Co. and can be used as an impregnating medium for plywood, Masonite, stone, asbestos, paper and other porous materials. It may, furthermore, be compounded with synthetic rubbers or with other types of synthetic resin. In the electrical industries, according to "Wire and Wire Products," 1944/19/368, it may be employed as an insulating coating for armature windings. The same issue of "Wire and Wire Products" refers also to **Paraplex G-25,** a new plasticizer possessing high resistance to oils, petrol and heat. It has shown promise for use in conjunction with polyvinyl chloride cable insulation.



MOTORS

Experimental tyre designed to save rubber has been developed and tested by the Stuttgart Automobile Research Institute (Zoeppritz "Automobil Techn. Z.," 1943/46/225. Also "Engineer's Digest," 1944/5/142 The rim is provided with an unsually deep cavity.

MISCELLANEOUS

Growth of balanced outlook in regard to plastics is indicated by text of a recent development by the Aluminum Co. of America. "Plastics do many things better than any other material; aluminum does many things better than any other material; the two can team up to do a better job in certain circumstances than either could do alone." In an account entitled "Lightweight Metals in Post-war Industry," J. M. Sharpe cites this statement ("Machinery," New York, 1944/50/153). **Properties of ethylene plastics and polyamides** are discussed by Rolfe in "Practical Engineering," 1944/10/60. **Vinyl-chloride resins** manufactured by the Goodrich Co. under the trade name of Geon have now been produced by the manufacturers in the form of a true latex-like suspension without the incorporation of any organic solvent. The dispersion strongly resembles rubber latex and is remarkably stable. It may be obtained in a clear or coloured form and can be applied to surfaces by brushing, spraying or dipping. **Under the name Pliolite S-1,** the Goodyear Tyre and Rubber Co. is producing, from a synthetic base, a replacement material for its pre-war brand of Pliolite manufactured from natural rubber. The range of uses for the new material is the same as that for the old, although at present it is available only for military purposes, principally for electrical insulation. A special type of synthetic constitutes the base of the new form. **Stresses in bent circular shaft** with holes in the plane of bending (design frequently used in modern machinery) have recently been investigated by Frocht by the method of three-dimensional photo-elasticity ("Journal of Applied Mechanics," 1944/11/A10). A simple method of calculating such stresses is presented and a comparison of the stress concentration factors with pub-

lished results from fatigue tests and strain measurements from large steel shafts is given. **Cemented lap joints,** widely applied in assemblies of wood, plastics and metals, have recently been investigated from the theoretical standpoint by Goland and Reissner (" Journal of Applied Mechanics," 1944/11/17). Stress investigation in the joints involved determination of the loads at the edges of the joint and stresses in the body of the joint itself. Solutions are obtained for the limiting cases of very thin cementing layers and heavy cementing layers. **Problem of laminating large parts and assemblies under low pressure** is dealt with by Willcox in " Product Engineering," 1944/15/386. The properties of high- and low-pressure moulded laminated fabric are compared for a laminated phenolic-base plastic, the low-pressure moulding employed being produced at 75 lb./sq. in. For the low-pressure material, impact strength was reduced by 2 per cent., bend strength by 7 per cent., compressive strength by 31.5 per cent. Big reductions in elastic modulus occurred and water absorption for 24 hrs. was doubled. Specific gravity was only slightly less. **Design of low-pressure mouldings** is considered, in the same account. Featured also is an account by Simmonds of Durez Plastic and Chemicals Inc. on the **shrinkage of plastics** and what proper measures should be taken in the designing of moulds and the locating of inserts to allow for this not very desirable property which is exhibited both by phenolics and thermo-softening resins. **Novel semi-cylindrical cover** for case of master setting and checking rolls for micrometers is featured in advertisement by Sav-way Industries (Products Division), of 4875 East 8-Mile Road, Detroit, in " Automobile Topics " for July, 1944. The cover fits over the wooden base housing roll set and is executed in a transparent plastic. **Short review of non-metallic materials** used in the metal industry is given by Bell in " Metals and Alloys " for January, 1944. The reference table of new materials and finishes appearing on the market during 1943, which appears in the same issue of " Metals and Alloys " and is compiled by Peters, lists about 14 new non-metallic materials of construction and 39 new types of finishes and coatings. **Conversion of heavy three-high sheet-metal rolling mills to plastic bearings,** is recorded by Fuessgen in " Kunststoffe," Vol. 20, 1943, p. 250. The bearings in this case were on a laminated cellulose basis—a German substitute material for laminated cotton fabric. **Thiokol A** is being produced in fair quantities by a new concern in Sweden and is also finding use there as a packing medium for insulation purposes and for rubber hose and rubber soles. A factory at Gilslared in Sweden is turning out **Telex, a combination of Thiokol and Neoprene,** by the Ehren-Nilsson process; production is planned at 200 tons annually. At Ljungaverk, too, a factory is being built for the production of 400 tons of Neoprene annually, according to Svedberg process (" Foreign Commerce Weekly," 1944/15/27). Latest development in new uses for transparent **regenerated cellulose film** appears to be in the form of **bandages impregnated with drugs of the sulfanilamide type.** The transparent dressing enables constant supervision of the wound to be maintained, makes for rapid inspection, and enables the effects of the treatment to be followed at every stage. The effect of the impregnating medium is to destroy most types of surface infection. **Use of plastics in women's footwear** is featured largely in an exhibition of American textiles in Manchester. (This closes on September 15.) One type of shoe exhibited is soled in a transparent plastic claimed to be more resistant to abrasion than leather itself. It might be recalled that some four years ago an English manufacturer was using transparent plastic for the heels of fancy shoes. Also shown at the exhibition is a so-called **paper blanket,** said to be composed of cotton, felt and resin; besides being impermeable to draughts, this material is claimed to possess high thermo-insulating powers and good wearing properties.

INCREASING PRODUCTION with SYNTHETIC RESIN ADHESIVES

Spot Gluing with the High Frequency Heating Gun Developed by Messrs. Pye Telecommunications, Ltd., Cambridge

THIS high frequency gun makes it possible to apply heat locally to a synthetic glue so as to cause it to set rock hard within a short space of time. The area heated by the gun is circular with a diameter of about ¼-in. The adhesive outside the heated spot is unaffected in properties, and if the correct type is used will eventually harden at shop temperature to produce a complete bond.

It is thus possible to build up an assembly in a jig by " spot gluing " and to remove it from the jig immediately. Overall setting of the adhesive then takes place whilst the assembly is awaiting further operations.

When building ribs and similar aircraft structures the plywood biscuits can be rapidly " spotted " in place with the gun and the use of brads avoided.

Similarly, plywood stiffening strips can be fixed to plywood skins. The strip is coated with adhesive and held in place on the skin in a simple jig. The gun is then applied for a few seconds (the time depending on the thickness of the plywood used) to spots at a pitch of 1-1½ in. The cured spots hold the strip firmly in place and eliminate the use of clamps or other pressing devices whilst the remainder of the glued area hardens normally.

The high frequency gun simplifies the operation of laying up tailored veneers on a shaped mould for the production of plywood of double curvature.

Considerable difficulty is experienced at present in the edge gluing of successive veneers together on the mould. The standard practice of heating the glue line with a soldering iron and applying side pressure by hand is slow and somewhat uncertain. Paper tape or metal staples can be used but must be located in positions where they can be removed so that they do not remain in the finished article.

By means of the high frequency gun the veneers can be spot glued together with rapidity and security. The spots are widely spaced in places where the curvature is slight and are crowded together where curves are severe.

Synthetic resin glues such as Aerolite 304F are particularly suitable for this operation although skin glue and formaldehyde can be used.

Description of Apparatus

The radio frequency power of about 100 watts at 170 megacycles is supplied by a self-oscillator which together with its power unit is housed in a steel case 10 ins. by 8 ins. by 18 ins. (see illustration). The high frequency power is applied to the work by means of a gun connected to the oscillator by a flexible concentric transmission line.

The power is automatically switched on when the gun is pressed on to the work, and is then automatically switched off after a predetermined interval by a timing circuit in the transmitter unit. The time interval can be set at any value up to 12 secs., by a dial on the transmitter. The time required to cure the glue depends, of course, on the thickness of the veneer, but glue lines beneath 2 mm. veneers may be cured in 2 secs. The apparatus is designed to work off a 190-240 v. 50 cycles supply

(Continued on page 449)

Plastics and the Pottery and Glass Industries

THE recent important news regarding the development by the well-known American glass manufacturers, the Owens-Corning organization, of glass-plastics constructions, brings to mind several existing and possible complementary usages of these two materials. We have, too, before us every day, examples of plastics replacing pottery and glass where the latter labour under certain disadvantages, and, of course, many instances where plastics have carved new niches for themselves where the inorganic materials could not enter for a diversity of reasons.

While it would be folly to presume that plastics can seriously affect the volume of pottery and glass output, yet the progress of our industry vis-à-vis the age-old one is not without piquant interest. There is, moreover, a parallel between the two spheres in that both are plastic industries. In entering upon this type of discussion, it is well to remember certain salient, though often obvious, facts.

(1) As a result of research, there will be considerable advances in the production of both the organic plastics and the inorganic glasses and pottery, but for reasons such as the much larger and universal employment of scientists in the first-named field, and the greater difficulty of research work in the second, it can be assumed that the rate of improvement in plastics will be the more rapid.

During the past 50 years (we almost wrote 1,000 years) there have been but few new and important developments in the inorganic field of manufacture, and we see only the boron-containing high-temperature glasses typified by "Pyrex," toughened glass, optical glass, glass fibre, safety glass and steatite mouldings as having reached important stature. Fused silica was a remarkable advance, but production and use is on a small scale and we may yet see bentonite paper and cutting tools made from sintered alumina. These are important, but in a much shorter period and starting from scratch, the plastics industry has produced dozens of completely different plastics, all of them important, and hundreds of variations—a result of the ease of organic synthesis compared with the difficulties inherent in producing new inorganic variations.

(2) The great advantages of the inorganic substances are hardness, transparency (glass), resistance to water (glazed pottery and glass), to acid and to heat. From the production point of view, there is low cost, while the supplies of raw material, china-clay, sand, soda, etc., are truly inexhaustible. The great disadvantage of glass and pottery, with the exception of special glasses, is comparative fragility accompanied by an element of danger, which may be negligible or important according to circumstances.

(3) Compared with glass and pottery, plastics possess the disadvantages of low heat resistance (it is unlikely that any plastic will ever be made with a heat resistance much over 200 degrees C.), generally lower water- and acid-resistance, and they are softer. In one or two instances, transparency is as good as optical glass; it is, however, doubtful whether this high standard can be maintained so long as optical glass, but this is not so serious a drawback as it seems, and improvement will take place. One or two plastics have very high water resistance.

From the production point of view, the supplies of raw material for plastics manufacture are limited, being mainly produced from coal, petroleum, cotton and wood, the industry buying therefore in competition with those engaged in fuel,

chemical, textile and other production. It is probable that production of chemicals for plastics from coal may need special consideration with the creation of a new gasification industry.

Pre-war the total figures of production of plastics in this country was of the order of 30,000 tons per annum and was rapidly increasing. While these figures seem woefully small compared with those for glass and pottery production, it must be remembered that plastics will, weight for weight, go twice as far as glass; moreover, as exemplified in the U.S.A., where, in some four years, production of synthetic rubber was stepped up from a negligible figure to nearly 800,000 tons per annum, given the plant and the technicians, expansion can be very rapid.

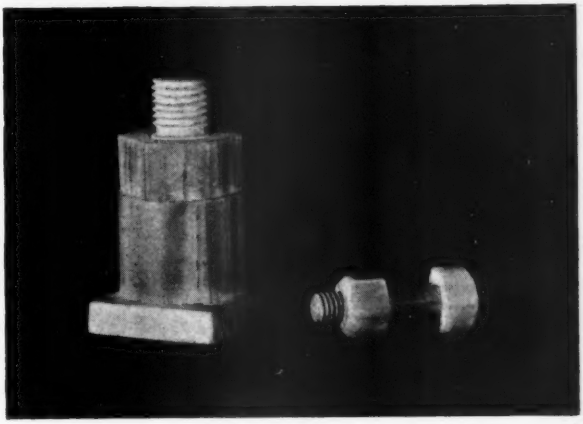
The greatest advantage of plastics is their mouldability to small tolerances, that is, precision moulding. A given complicated object can be turned out of a press from a single or multiple die according to the size in one or more minutes, according to thickness. With the exception of removal of a little flash and subsequent inspection, the object is generally ready for packing. Compare this with the half-dozen or more treatments, stamping, drilling, cleaning, sand-blasting, plating, etc., that metal undergoes before it is ready for sale.

A word may be said here of the strength of plastics. They are much less brittle than glass, but even when they do break there is no danger from flying splinters. There is also this to say: a properly designed plastic object is more "unbreakable" than a badly designed one. Finally, new plastics are now on the market which are sufficiently strong to warrant the expression "unbreakable." A hard hammer blow may dent them but will not splinter them. This type is not transparent.

(4) Too much stress should not be laid on the high cost of plastics. It is

The forming of fuselages made of glass-fabric / plastic laminations by the rubber bag process.

(Courtesy "Automotive and Aviation Industries.")



British example of glass fabric / plastic units.

important to realize that costs may be lowered with increased output. For example, the synthetic rubbers were about 5s. or more per lb. pre-war. Post-war synthetic rubber has been promised at 15-20 cents per lb. More important is the fact that ingenuity in design and ingenuity in thought as applied, say, to erection may so revolutionize cost as to make raw material price of least importance.

While this is no place, and the writer has not the ability, to compare production costs in the two industries, it must be also remembered that the plastics moulding industry works at a maximum of about 170 degrees C. as against over 1,000 degrees C. of the pottery and glass furnaces, nor is there any lengthy drying period, as is necessary in making pottery. Finally, the plastics industry is probably more mechanized than the pottery and glass industries.

It is true, of course, that pottery, and often glass, manufacture are arts. The plastics industry is far from reaching the same stage; we cannot yet produce even a simple two-colour moulding, much less a saucer with a secondary coloured and complicated design on it. It is mechanically impossible also for it to reproduce even a copy of the wonderful Prince Rupert head by Dwight that is in the British Museum and which was produced in clay by the touch of a man's little finger.

With these premises we may now make an estimate of the sympathies or antipathies between the two industries. We use the word antipathies advisedly, for these must be present when one industry attempts to substitute one material for another to the detriment of a second industry. Such replacements have taken place since the beginning of time. Some have been justified; others have not, and fortunately have been relegated to the limbo of deservedly lost endeavours, for the inferior can have no permanent place in this modern world.

On the whole, those plastic " replacements " that have succeeded have not been replacements at all but rather those instances where glass and pottery have not hitherto been employed because of their inherent disadvantages, just as much as plastics, for example, can never be used to make casserole dishes.

Complementary Uses

We have already alluded to the combined use of glass and plastics by the Owens-Corning organization of America. Much work on the subject has also been carried out in Great Britain, but this seems to be confined to the electric field.

An excellent summing up of the American work was given by F. W. Preston in a paper delivered early this year before the Society of the Plastics Industry, in New York, entitled " Significance of New Data on Combinations of Plastics and Glass Fibres." As is now

well-known, the new combinations are made by bonding glass fabric with plastics, the enormous strength of the fibres and the flexibility of the plastic producing an entirely new structural material which must be considered essentially as a glass structure supported by plastics and not the reverse. The plastics protect the fibres from abrasion. They also act as a bridge by which stress may be transferred from one fibre to another and by "hydraulic action" permit the glass fibres to operate in tension under favourable conditions. With a tensile strength of 50,000 lb./sq. in. and Youngs Modulus of 3,000,000 lb./sq. in. the material gives great promise of future use. The latter figure is low compared with metals, but we now have a gain in flexibility and the result is extremely high shock resistance. The first development is a structural material in experimental aircraft. The possibilities seem to be great in the automotive and allied industries.

There have already been occasions when both plastics and pottery or glass can be employed in the one unit to the advantage of one or both. Were we to examine the problem closely and with full knowledge of the advantages and disadvantages of each, it is quite possible that occasions will arise when even new and hitherto unconceived uses may be introduced.

Early Union of Glass and Plastics

The oldest and unique example in the past of this union is that of safety glass, which reached an extremely high state of excellence and development after passing through the early stages of gelatine and celluloid interlayers. It would be a brave man who could say that plain glass sheet would still have been used in motorcars had not the "sandwich" been invented. It is just as likely the pure celluloid, cellulose acetate or mica sheet would have been resorted to.

It may be that one day the production and quality of sheet glass will be so much improved, the technique of safety glass production so simplified and speeded up and the cost of resins so cheapened that much wider application of this important invention will be possible. We should then have the side windows of all omnibuses and possibly shop windows made of safety glass. Another immediate application would be in the construction of glasshouses, or will the industry sit back and await the certain coming of the plastic window with a sufficiently hardened surface which would theoretically eliminate both sheet and safety glass? Already in the U.S.A. there have appeared a series of new plastics—the Columbia resins—which are transparent and much more unscratchable than the organic "glasses" now used in aircraft.

Plastics and Glass Protection

Another direction in which combination of plastics and glass may prove of benefit is the possibility of providing a plastic and/or elastic edge to glazing in order to lessen vibration or to avoid puttying. We are, however, far from knowing everything about the life of plastics under continued extremes of weathering.

An interesting development which showed that plastic manufacturers are not blind to the disadvantage of plastics was the production in 1938 of combinations of plastics and glass for domestic ware. Thus in a condiment set produced by a London concern the main holder, salt and pepper set were of plastics, but the mustard pot consisted of a glass-lined container in view of corrosion.

From an entirely different aspect it may also be worth while examining the use of plastics for packing, so that objets d'art, crockery, sheet glass, etc., may be transported with the minimum of space commensurate with safety. The suggestion is that the objects be dipped in or sprayed with a solution or emulsion by which they are coated with a tough film readily removable on arrival at the destination. It is perhaps hardly necessary to stress the advantages of such a film with the elimination of bulky packages in which old newspapers, straw and wood shavings seem the principal ingredients. Admittedly the latter are cheap to

buy, but it is by no means impossible that a proper analysis of the labour involved and the cost of transport of bulky packages would not place plastics glaringly out of court.

Substitutes for Glass and Pottery

Let us first clear our minds regarding the meaning of the word "substitute." By some queer thinking on the part of the general public a substitute is considered as something inferior to the thing it replaces, whereas obviously it can mean "equal," "superior" or "inferior." Thus we all agree that when steel substituted wood for ship building we had a superior product. When celluloid combs substituted real tortoiseshell ones this might be translated as an inferior production. This, however, is debatable since, apart from making an excellent comb, celluloid also widened the market to a public that could never buy real tortoiseshell.

The substitution of glass and pottery by plastics will also be hotly argued. The "genuineness" or "worthwhileness" will appear in the course of time when true value in regard to function, length of life, price, etc., can be examined by experience.

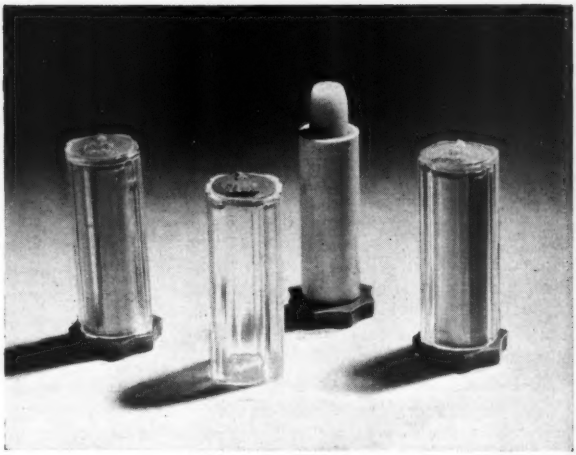
In the meantime we may enumerate in no special order some of the plastic objects that have appeared on the industrial scene, and, except for a few remarks on each, we may leave the reader to judge their worth.

Domestic Ware

It is not necessary to dwell too long on this section since the reader knows as much as the writer on this subject. Cups, saucers and mugs in plastics are almost restricted to the picnic and nursery trade, where low weight is important and danger due to breakage negligible. The brake on big extensions in these lines are the limits of raw material production and absence of pictorial design. Improvement in the first situation lies in the laps of our industrial gods. Improvement in the second is possible but only by the adoption of the "china" technique, namely, the impression of a secondary design by painting with paints and enamels of very improved type. The heat-transfer coefficient should be altered, say, by the inclusion of silica filler. Heat-resistant plastic "crockery" will probably never appear, but resistance to water and cleansing process will be improved.

In spite of the drawbacks of plastics, there is little doubt that the picnic

Polystyrene Tiles make this decorative wall.
(Courtesy Monsanto Corpn.



The modern plastic cosmetic container is one of the most attractive productions of modern industry.

and nursery trade has come to stay and will steadily expand.

Tiles

There is a good case for the moulded plastic roofing tile if only from the point of view of lightness. A plastic tile of the same size as a Broseley tile would weigh about 1-1¼ lb., against 2½ lb. A plastic tile only ⅛ in. thick is perfectly easy to mould, would be quite strong enough for the job and would only weigh 4 oz. This, presumably, would eliminate the necessity of heavy roofing structures to bear the weight of the tiles, and, therefore, lower house-building costs. Moreover, since water absorption of plastic tiles is negligible, this is important in working out these structural strengths. Again, larger tiles than the Broseley type are easily possible, thus saving in overlap, and breakage in transport would be very low. Tile for tile, the plastic type would, of course, be expensive.

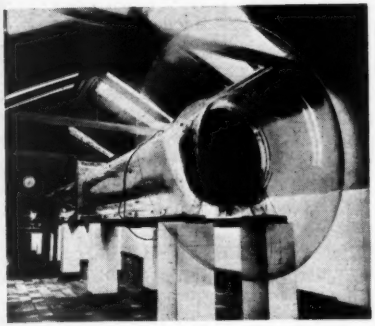
It is doubtful whether adoption of such a type is possible, except for special demands in view, again, of the raw material situation.

A different condition may arise in the field of bathroom tiles. Here we have resins that would be quite suitable from the water-resistance point of view and would not be more expensive than the glazed porcelain tile. The technique of making a wall from a plastic tile would, in view of high humidity, probably have to be analogous to the present method, namely, the use of an organic cement. There is also the possibility of utilizing large sheets of plastics.

An interesting experiment in the U.S.A., and one by which the inorganic tile industry is not affected, is the production of transparent tiles in polystyrene for the construction of decorative walls. Here the tiles have been moulded in a shallow boxlike form (5 ins. by 5 ins. by ½ in.), with wall thickness ⅛ in., and weigh about 1⅓ oz. each (the specific gravity of polystyrene is 1.05). The tiles are not cemented but clipped together and are hung on a frame, so that erection is simple and rapid and replacements due to breakage, which is unlikely, quite easy. The tiles are transparent and coloured in any shade and hidden lights give a pleasing result. While this type of structure may at first sight appear suitable only to the Kingdom of Hollywood, its possibilities in restaurants, hotels, theatres and cinemas are obvious.

Bottles, Containers, etc

The plastic container for cosmetics, pastes, etc., has come to stay. So beautiful and light are many transparent and opaque resins, and so easily mouldable are they by injection and other methods, that acceptance by many industries is an



(Left) Transparent research tunnel of Perspex.
(Courtesy Airscrew Co., Ltd.)

established fact. Moreover, beautiful light-reflecting effects equivalent to high-class cutting can be obtained by the design of the mould.

The normal bottle shape cannot be obtained by moulding, but recent investigations have proved that the blowing technique gives excellent results, and examples will certainly be seen in the next few years.

Some few years ago, one concern was started to produce milk bottles in plastics but never came into production. Presumably the bottles were to be of an improved "non re-use" type similar to the waxed cardboard "bottle."

Transparent Models

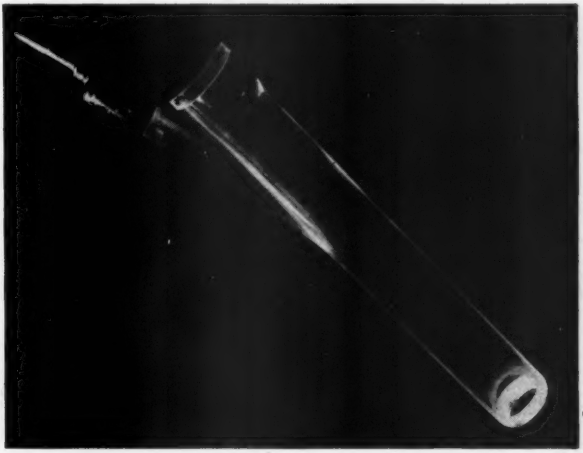
These came under the heading of ventures unobtainable in glass. Many engineering shapes have been cut from transparent cast resins, either for research or teaching, with excellent results, since a blue-print cannot give an accurate idea of "seeing how it works." A more ambitious structure is the air-tunnel of Perspex made for research work on industrial fans, which has been erected by the Airscrew Co., Ltd.

Surgical Instruments

Here, again, we have an example of objects which cannot, or least have not hitherto been made in glass. Polymethyl methacrylate is a transparent resin which, even in the curved form, can be made to carry light. This property has been taken advantage of to produce surgical lighting instruments which produce a "cold" light at the point of working. At one end, far from the seat of injury or infection, is the source of light. The actual injury can be touched with the end of the plastic instrument without burning, and being an excellent dielectric there is no danger of electric shorting.

Optical Organic "Glasses"

The past seven years has seen intensive work on the use of polymethyl methacrylate and polystyrene in this field, the



"Cold" Light
Perspex surgical instrument cut from the solid by Vann Bros.
(Courtesy I.C.I. Ltd.)

special advantages being that the first is equivalent to optical crown glass and the second to optical flint glass, and that both are mouldable to very close tolerances. They are being widely used in the construction of general optical equipment such as cameras, binoculars and projector systems, and almost every optician in the country to-day announces in his shop window that plastic lenses are available. Admittedly the plastics are much more easily scratched than glass, but this fault is not always serious where constant cleaning is not essential, by suitable protection from the air. As previously indicated, harder transparent plastics are on the way.

Horticulture

The use of large transparent plastic sheet in all aircraft is commonplace, but already in pre-war days there were experimental attempts to introduce this type in motorcars in place of safety glass. An exhibit of a Rolls-Royce car in one of the British Industries Fairs showed a curved expanse which eliminated view-obstructing pillars.

A more ambitious example was seen in the observation car of The Royal Scot and consisted of an unbroken curve the width and height of the very capacious carriage.

While these may not be introduced on a large scale, we believe that sheet plastics are of definite promise in the field of horticulture. Already the "cloche" industry has been affected, one well-known production consisting of a thin sheet of cellulose acetate carried on a wire mesh, and expansion would appear imminent by the introduction of new designs using thicker sheet.

If plastic glazing is ever adopted it is surely in the glasshouse industry where it will first be used. Here, again, a harder surface is necessary in view of the habit of whitewashing glass that seems so prevalent.

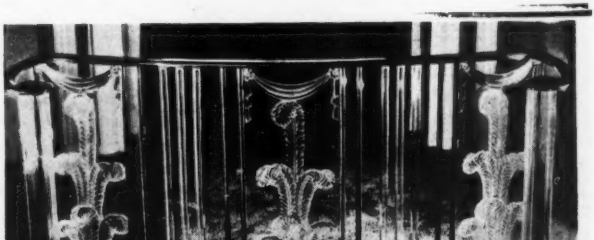
Flower pots in plastics have already been made. They are slightly more expensive, but their life is considerably longer than the earthenware type. It has been stated that they are not porous to water and air. That this is a disadvantage is not borne out in practical trials, the hole in the base, especially when made in the form of a star, being sufficient to allow water to pass out and air to pass in.

Lamp Shades

Plastic shades, in view of their lightness (due not only to low specific gravity but the extreme thinness in which they can be moulded) and consequently low breakage figure, have gained enormously in popularity. This is also marked in the fabrication of fluorescent light fixtures because of exceptional clarity of the transparent type and high refractive index.

Miscellaneous

An experimental "stunt" of an amusing character was the production of a plastic mirror made by the silver backing of a transparent plastic. It had been hoped that a mirror which guaranteed



An example of plastic art in polymethyl methacrylate.

"no seven years' bad luck" might prove attractive. Another amusing but quite a sensible idea was the fabrication in the U.S.A. of transparent hospital bassinettes which gave ample warning to the nurses of impending malfeasance and also a chance to the infant to observe the quaint doings of grown-ups in the cage outside.

Art

It is to be hoped that artists may come to regard plastics as a raw material worthy of examination. The materials have already shown much promise, as both cast and sheet forms lend themselves so readily to turning and cutting. The late Lady Margaret Crawford made many beautiful specimens from "Perspex," while the balustrade seen in the last illustration shows the modern work of Americans.

An unusual adoption of cast resins took place at the recent U.S. Government exhibit at the New York Fair. Twelve statues each 9½ ft. high and each weighing nearly two-thirds of a ton were cast in rubber moulds. They were transparent and, lighted from within, gave a very impressive result.

Conclusion

It is hoped that the inclusion of so many examples will not give the impression that the writer sees any possibility of a twilight of the glass and pottery industries. The raw material position puts an ascendancy of plastics quite out of court. Indeed, the main promise of plastics lies in fields which glass has not entered.

Finally, these notes serve as an appeal to each of both industries to examine scientifically and technically the products of the other to ascertain where both may meet on common ground to open up markets at present attainable by neither alone.

SERVO SYSTEM FEATURES PLASTICS

(Contd. from p. 411)

ject of patents; two in particular are worthy of some detailed reference.

The novelty of the present system lies in this, that direct reaction is possible between the vacuum cylinder and the control valve. There is no lost motion between the pedal control and valve mechanism, and movement may be fully regulated throughout the whole of the operating cycle. Reference to Plan 1 will indicate how this object is achieved. Motion through the pedal is taken through the ball end, thence through the rocking end to the sliding shaft A, whence, through a lever system, movement is transferred to the valve mechanism as shown by the arrows.

Washer (8 ins. dia.) incorporated with plastic piston. It replaces the the leather component formerly used and is moulded in a soft rubber-like plastic.

The incorporation of plastics into this unit makes possible a comparatively large saving in deadweight. Together with fixing brackets (which are adjustable for height), and the 1¾-in. Lockheed master cylinder, the assembly with the 8-in. vacuum cylinder weighs, in all, only 21 lb. A unit of this type has now been in use on a large lorry carrying extremely heavy loads, day in and day out for 12 months, and has given every satisfaction. No wear of the vacuum cylinder has occurred and the rubber-like plastic washed has proved in no way inferior to the leather one formerly used. It may be pointed out that the plastic can be produced in a form more uniform than leather.

Stroke-time Diagrams in Moulding Practice

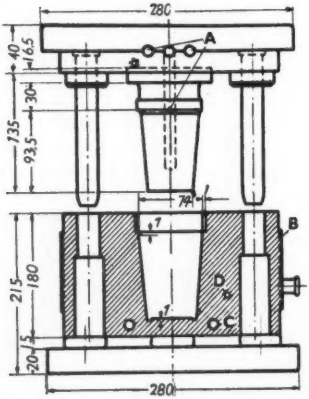


Fig. 1.—Test moulds for determination of stroke-time diagrams for moulding powders.

After Schwittmann in "Kunststoffe," 1944/34/1. Pressure-time and Stroke-time Diagrams are Distinguished, and Factors Affecting Them Examined.

IF a moulding powder be charged directly, without any previous preparation, into a mould and be subjected to pressure, then, as a result of the heat of the mould, it will, after a short while, soften; it is now in a condition to flow under the applied pressure from the movable part of the mould. The distance through which any particle of the mass travels in a given time as a result of the flowing process is referred to as the flow path. The total distance of flow which takes place until the mass finally hardens up is known as total flow. From the flow path may be calculated rate of flow.

As opposed to rate of flow, capacity for flow is just as much an inherent physical property of the material as colour, smell or specific weight. Just as the colour of a body may alter with time, for example, fading may occur, so, in just the same way, may the capacity for flow of a material vary.

The peculiarity of the synthetic moulding powders lies in this, that their capacity for flow may be varied so much that in a few minutes may be witnessed a transition from solid powder particles, through a liquid phase, to a uniform solid body. Capacity for flow is thus the most important practical property of a moulding powder. In so far as this property varies with time, it must be represented not by a simple coefficient, but by means of a diagram. The reciprocal of capacity

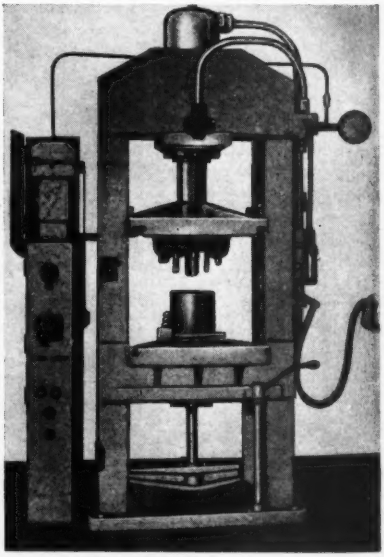


Fig. 2.—Hydraulic press used in conjunction with a mould shown in Fig. 1. At the left are recorders for stroke-time and pressure-time diagrams.

of flow, or fluidity, is viscosity, which is measured in poises.

Just as a distinction is made between ideal and real gases, so, in the case of liquids a distinction is drawn between those which behave as ideal fluids and those which behave otherwise. Thus, in the case of true liquids a linear relationship exists between the stresses required to produce deformation and the speed of that deformation. On the other hand, for clay, resin, glasses and many other liquids this relationship is not linear. This anomalous behaviour may be determined by direct measurement of flow capacity, for example, in Brabender's Plastograph, or in an apparatus developed by the authors. So far as the practical man is concerned, questions of this type have been of less interest than that of finding a good method for determining the mouldability of a powder.

In certain circumstances the mould closing time required when moulding a beaker-shaped form can give an indication of the moulding properties of the resin. Such a method, however, will not give a complete picture of the properties of the powder tested, for as soon as the charge is hardened then no further indications of its behaviour can be obtained in this way.

The latest and simplest method of this type is based on taking a known weight of the moulding powder, placing it between two flat plates and pressing it out into a disc, the diameter of which serves as an indication of total flow or of flow factor. This method is still in wide use, but obviously suffers from many disadvantages, for example, the specific load on the mass diminishes during the course of the test as the diameter of the disc increases. This disadvantage is avoided by the flow test of Krahl and in the American flow test. In both of these methods the moulding powder is pressed from the die cavity into a channel lying in the direction of pressing. As a result, small rods are produced, the length of which serves as a measure of the flow capacity of the powder.

Data on capacity of flow of this sort is of the utmost value to the holder in so far as it serves to indicate to him whether a moulding powder is suitable for the production of relatively flat or tall mouldings. On the other hand, measured in this way, the figures obtained give no indication of pressure requirements or speed of curing. The three properties, however, are all intimately linked and of equal importance, hence, in devising their apparatus, the authors have seen to it that all three are simultaneously evaluated.

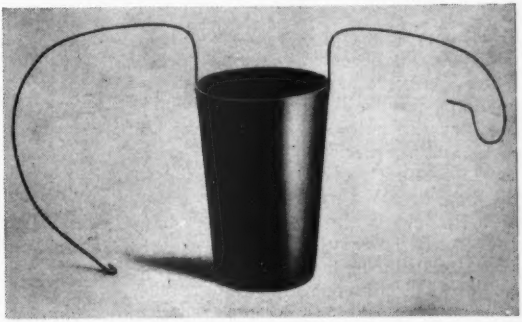


Fig. 3.—Test beaker produced in mould shown in Fig. 1. Filament-like flashes result from partial escape of the excess charge. Before the total excess was rejected, however, complete hardening had occurred, hence the cylindrical extension to the upper part of the conical portion of the pressing.

In form, the test piece mould is of conical shape, as shown in Fig. 1, the height of the die cavity being 96 mm. with a diameter at its wider part of 74 mm. and at its lower part of 56 mm. On the lower part of the mould, from the upper edge to a distance within 1.5 mm. above the point where the cylindrical filling

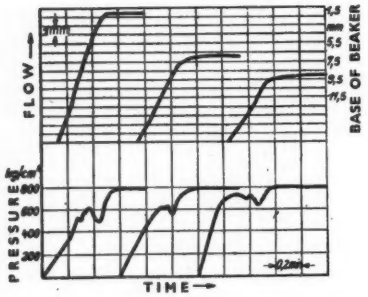


Fig. 4 (above).—Pressure - time and stroke-time curves of three different moulding powders at 160 deg. and for a pressure of 800 kg/cm².

cavity curves into the conical portion, are milled two adjacent semi-circular slots 1 mm. deep; through these, any excess moulding powder is discharged. Moulding is carried out on a 100-ton hydraulic press, and in order to determine the pressure a pressure recorder is attached. At the same time, the path of the upper part of the mould is also recorded by means of the usual lever system. The complete apparatus is shown in Fig. 2. The mould is electrically heated, temperature regulation being by means of remote control with a thermostat.

Experimenting Technique

Eighty gm. of the moulding powder to be investigated is charged into the lower half of the die, the upper half being then immediately lowered. In the heated mould, the now plastic mass flows beneath the applied load and passes into the beaker-shaped die cavity until this latter is completely filled.

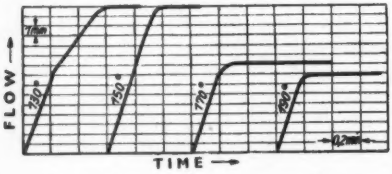


Fig. 5.—Stroke-time curves at various moulding temperatures for a moulding powder with high flow factor.

For the moulding of a normal beaker, 40 gm. moulding powder would be sufficient. The charge introduced, however, is twice this amount and part has, necessarily, to flow out through the slots between the upper and lower halves of the mould. The entire excess, however, cannot escape in this manner, as simultaneously with the softening of the charge, hardening also commences; thus

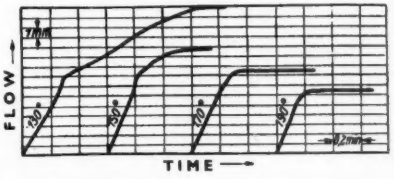


Fig. 6.—Stroke-time curves at various moulding temperatures for a moulding powder with medium flow factor.

Fig. 7 (above).—Stroke-time curves at various moulding temperatures for a moulding powder with poor flow factor.

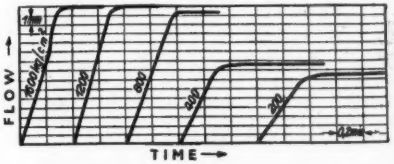


Fig. 8 (above).—Stroke-time curves at different moulding pressures and at a moulding temperature of 160 deg. C. for a moulding powder of medium flow factor.

the quantity ejected is affected both by capacity for flow of the mass and its rate of hardening. Flow capacity is a measure of the rate at which the excess may escape, whilst speed of hardening governs the possible duration of the overflow process.

Fig. 3 shows a specimen beaker complete with the flashes produced in this way.

In the example shown, the moulding powder has cured before all the excess charge had been expressed; the beaker is, therefore, more than 96 mm. in height and carries above its conical walls an additional cylindrical part. Furthermore, its base is naturally thicker than would normally be the case. The thickness of the base in the case of various test charges may be seen from the stroke-time diagram reproduced in Fig. 4.

In order to determine the effect upon stroke-time curves of the numerous factors which arise in actual practice, measurements are carried out in a variety of ways. Various moulding powders produced by different manufacturers are taken, each being characterized by varying flow factors. Initial pressings are made at 160 degrees C. and at a pressure of 800 kg./cm.^{2} Fig. 4 gives the pressure-time and stroke-time curves.

Fig. 9.—Test beakers etched with silver nitrate to reveal macrostructure. In the beaker at the left no well defined flow has occurred, whilst in the beaker at the right pronounced flow has taken place and the mass exhibits a preferentially orientated structure.

So far as the stroke-time diagram is concerned, the first moulding powder tested shows very prolonged flow, the curve extending almost to the extreme of the test; thus, of the 80 gm. charged into the conical mould some 50 per cent. is expressed in the form of a flash; the beaker which results is thus of quite normal form, the base being but slightly thicker than the expected value. Under these conditions, had true theoretical values been reached the base would have been 1.5 mm. thick and the weight of the beaker 40 gm. Incidentally, powders of even more pronounced capacity for flow could be selected, but, under the conditions of test would yield less valuable data. So far as initial flow is concerned, this commences as soon as the pressure begins to rise, but the first part of the flow can be ignored in measurement, as, in practice, it is of little interest.

The second powder investigated exhibits a considerably smaller flow factor. The initial part of the curve is slightly flatter than in the case of the first moulding powder, hence the angle it makes with the time axis is less acute. The tangent of this angle is a measure of rate of flow for the moulding powder concerned and, hence, for its capacity for flow. The flow curve for the third powder examined is even shorter than in the case of the second and the break in the curve is still more pronounced; thus, clearly, flow is slower in this instance than in the two previous examples.

As we have already noted, the result of heating the charge in the mould is, first, to cause it to soften and then, finally, to harden it permanently. Thus, mould temperature becomes a factor of the highest importance. Fig. 5 shows how the flow path of a moulding powder of good flowing properties varies when the mould temperature is raised. At 130 degrees C. it will be observed that, whilst in the first part of the curve, flow is relatively pronounced, it cannot be considered as satisfactory, for, at this temperature, the moulding powder is extremely viscous and undergoes plastic deformation only very slowly. Total flow, however, can be recorded only within the capacity of the measuring instrument, and would probably be greater than that indicated on the curve.

At 150 degrees C. flow capacity is obviously improved. Total flow, as indicated on the diagram, is again limited

by the capacity of the measuring instrument, but obviously it is less than that for 130 degrees C. At 170 degrees C. the total flow path has been markedly shortened as a result of rapid hardening. At 190 degrees C. total flow is still less.

Moulding powders of medium-flow properties exhibit similar temperature relationships. In Fig. 6 similar diminution in flow capacity at 130 degrees C. is indicated by the second part of the curve. At 150 degrees C. flow has ceased after half a minute, hence the total flow path is quite short. Finally, at 170 degrees C. the flow path is shorter still, whilst at 190 degrees C. flow ceases after 0.2 minute.

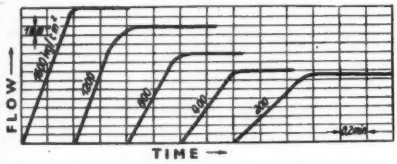


Fig. 10 (above).—Stroke-time curves for various moulding pressures and at 160 deg. C. for a moulding powder with high flow factor.

Fig. 11 (right).—Stroke-time curves for various moulding pressures and at 160 deg. C. for a moulding powder with poor flow factor.

Masses of poor flow capacity behave quite differently. At 130 degrees C. small capacity for flow and prolonged hardening time are observed. At 150 degrees C., however, both of these properties have simultaneously changed and the mass now behaves in a manner similar to that exhibited by resins of medium-flowing quality. Subsequently, the flow path remains practically constant and even the hardening time does not become shorter, having reached its minimum value at 150 degrees C.

Pressure Relationship of the Stroke-time Diagram

Apart from temperature, pressure constitutes the most important factor in moulding, although, it is true, flow capacity is little affected, for the effect of high pressure is to increase internal friction in the mass and thus diminish flow capacity. On the contrary, rate of flow is markedly increased. In Fig. 8 the effect of pressure is illustrated with respect to readily flowing moulding powder. Stroke-time curves are given for pressures of 1,600, 1,200, 800, 400 and 200 kg./cm.^{2} The 1,600-kg. load gives the steepest curves and, with diminishing loads, the curves become flatter. At 1,600 and 1,200 kg./cm^2 flow path is so long that it falls outside the capacity of the measuring instruments used. At 800 kg./cm.^{2}, however, it comes within range of the apparatus and at 400 and 200 becomes so short that it resembles the flow path of a mass of poor-flowing qualities subjected to a pressure

Fig. 12.—Beakers moulded from powders of varying flow factor in moulds of modified design. Height of conical pressing is proportional to flow factor. Charge in each case equals 20 gm. of moulding powder.

of 800 kg./cm.^{2} The flow path at 1,600 kg./cm.^{2} is especially noteworthy in that the upper part of the curve is steeper than the lower part. Whilst the lower part of the curve was being described, the charge was rising in the die cavity between the upper and lower portions of the mould, where sufficient space was available to eliminate any excessive friction effects. Later, however, movement had to take place in a more confined part of the die cavity, hence friction effects were manifested. Thus, in comparing Fig. 5 and Fig. 8 it is to be noted that the courses of the upper parts of each of these curves are in opposite senses. In point of fact, the increased flow rate shown by the break in the first curve in Fig. 8 is due to segregation occurring at high rate of flow.

Flow Lines

In Fig. 9 flow lines have been made visible by etching with silver nitrate. Moulding powder from which the beaker on the right was moulded possessed good flow capacity; the charge distributed itself

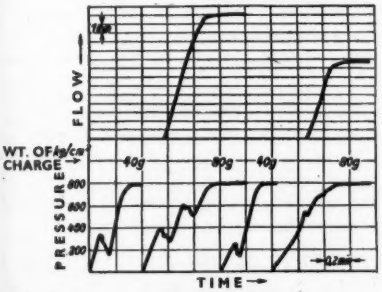


Fig. 13.—Curves showing effect of weight of charge on form of pressure-time and stroke-time diagrams.

rapidly under pressure in the mould, hence quite well-defined lines of flow are shown. In the case of the beaker on the left, however, the charge flowed neither so rapidly nor so readily, hence the macrostructure which results is entirely different.

Where ready and rapid flow takes place, perfect orientation of the filler particles occurs, their major axes tending to arrange themselves preferentially in the direction of flow. Furthermore, the resin molecules themselves tend similarly to orientate themselves, and before the hardening process is completed a more or less fibrous structure is produced.

Now, if hardening takes place with a mass virtually in a stationary state, linkages occur within it at random in all directions, where, however, flow or preferential orientation occurs, then clearly

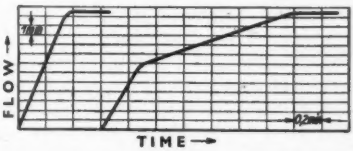


Fig. 14. — Stroke-time curves for two moulding powders of equal capacity for total flow; it will be observed from the form of the curves that in spite of this the course of flow is radically different in each case.

the resulting mass will exhibit marked directional properties. In particular, before hardening has finally been completed even viscosity will vary according as to whether it be measured parallel to or at right angles to the direction of flow. Thus, the steep upper portion of the stroke-time curve in Fig. 8 may be attributed to the fact that preferentially orientation produces a consequent diminution in viscosity.

However, it is to be observed that whilst the mechanical properties of the resulting mass are improved for directions parallel to that of flow they are diminished for directions at right angles to flow. This phenomenon is observed in the case of injection-moulded test pieces and is, furthermore, shown on subjecting experimental beakers to fracture by impact. However, it should be pointed out that the decrease in strength observed with preferred orientation is to be accounted for chiefly by the more pronounced non-hydrostatic reaction of the charge in the mould.

It will be observed from Fig. 10 that,

at very high pressures, a moulding powder of medium-flow quality gives a longer flow path than a good-flowing moulding powder subjected to half the pressure. The practical man is well acquainted with this fact and if a tall moulding must be made with a powder of poor-flow properties, then, it is considered, the pressure must be correspondingly raised. This procedure does not always lead to the desired results. From Fig. 11 it will be seen that increase in pressure to many times that normally used leads to no good results, and raising load from 800 kg./cm.^{2} even to 1,600 kg./cm.^{2} will be seen to have had but little effect upon the flow path. True, the slope on the curve is steeper and the speed of flow very much higher, but the overall effect is practically negligible. Comparison of Figs. 10 and 11 will make it clear that in one case pressure has altered the slope of the curve, and in the other its length.

It would be wrong to assume that the effect of the pressure increase on a mass of poor-flow quality would always be so insignificant as this. However, such is the case for a great number of the more difficult moulding powders; hence, the matter has been raised here. Above all, it is dangerous to generalize for method of production of the moulding powder, nature of catalysts present, and lubricant used can all produce varying effects and so lead to wide differences in otherwise similar moulding powders.

Relationship of Flow Path to Moulding Section

Determination of the relationship between height and flow and section thickness is difficult and many varied figures have, in the past, been given. For this reason the testing apparatus was modified in such a way that at full stroke of the press both parts of the mould would come into direct contact. If into the mould at correct temperature a given weight of powder be now introduced, say, 20 gm., and the mould closed, then on applying pressure the softened mass is squeezed continually higher in the mould as the two halves approach, the resulting beaker becoming thinner and thinner in section. This process will terminate when the resin is finally cured.

Apparatus of the type described is specially suited for this measurement as the wall thickness can be varied by altering the weight of the charge, whilst the conical form of the moulding is most convenient from the standpoint of production and operation of the mould under a wide variety of conditions. One minor problem which this shape settles is that of seizing together of the two parts of the die which does occasionally happen if a cylindrical form be used.

In Fig. 12 are shown four beakers moulded from powders of different flow properties. The test was carried out by putting 20 gm. of the power in the mould and determining to what height the moulding would run. The same test was carried out with loads of 10 gm., 30 gm., 40 gm., 50 gm., 60 gm., 70 gm. and 80 gm. It was observed that, with the heavier charges, disproportionately massive flow made its appearance due to delayed hardening.

Dependence of Stroke-time Curves on Mould Closing Time

To determine the effect of die closing time on flow of the material experiments were tried out on a number of different types of press. Here, however, in spite of variations in mode of operation, all presses were found to yield roughly the same results as shown in Fig. 14.

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PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

BRITISH SHELLAC BLEACHERS' ASSOCIATION.—Owing to the pressure of other work, Mr. A. J. Gibson, acting hon. chairman of the British Shellac Bleachers' Association, is relinquishing his connection with the Association as from September 30, 1944. All communications after that date should be addressed to the deputy chairman, Mr. A. F. Suter, of Messrs. A. F. Suter and Co., Victory Works, 83-84, Eastway, Hackney Wick, London, E.9.

KALLODENTINE.—A recent bulletin published by Imperial Chemical Industries, Ltd., under this title deals with the I.C.I. acrylic resins specially prepared for the production of teeth. Kallodentine is supplied in one clear and five tinted powders from which blending may be performed with liquid. Adequate directions are included for the preparation of moulds.

GAUGE AND TOOL MAKERS' ASSOCIATION.—The annual general meeting of the Association will be held on Wednesday, November 1, 1944, and further details will be announced later.

The export committee has concluded arrangements with a large number of Empire, Dominion and foreign Governments, under which the Association will be notified of any trade delegations coming from those countries to Great Britain.

SIR HENRY LYON.—The death is announced of the well-known scientist, Sir Henry Lyon, F.R.S., who controlled the fortunes of the Science Museum for so long. He had been much interested in plastics and installed an excellent section dealing with them in S. Kensington. For many years he was a director of British Industrial Plastics, Ltd.

GEORGE COHEN, SONS AND CO., LTD., of Wood Lane, London, W.12, and Stanningley, near Leeds, have just acquired the whole of the plant and machinery of Suncole Works, Cinderhill, Nottingham. This plant was put down new in 1938 and only worked a few months. Designed for the production of solid fuel, smokeless briquettes and by-products from coal, it comprises rotary retorts, distillation plant, gas producers, very large conveyors, aerial ropeway, two 500-kw. turbo sets, two 25,000-lb. Babcock boilers, sidings and a considerable quantity of plant of a general nature. Everything is for disposal and a catalogue is available on application.

ASHDOWNS, LTD.—We have pleasure in announcing that the general manager, Mr. G. F. Bassett, of Ashdowns, Ltd., St. Helens, Lancs, has been appointed a director of the company.

MR. ARTHUR BERKELEY.—We regret to announce the death on August 13 of Mr. Arthur Berkeley, M.I.E.E., for many years chairman of The Micanite and Insulator Co., Ltd., and a director of Associated Insulation Products, Ltd.

During a visit to the Chicago Fair in 1893 Mr. Berkeley found that the manufacture of Micanite had just been commenced in the United States, and immediately grasped the possibilities of this new invention. In the year 1894, with his brother, the late Mr. Edward Berkeley, he undertook the introduction and distribution of Micanite products in Europe. They were subsequently joined in this venture by the late Mr. M. Mohr and soon after it was decided to manufacture Micanite in England, and a company was formed, which eventually changed its name to The Micanite and Insulator Co.

Mr. Berkeley was a man of charming personality who continued, in spite of his many administrative responsibilities, to take a personal interest in the development of the business. He became very well known during his long and successful career and his colleagues have lost a friend for whom everyone had the greatest affection and the Industry one of its most prominent leaders.

INSTITUTE MEETINGS.—The following meetings of the Midland Section of the Institute of the Plastics Industry will take place during September and October:—

Friday, September 22, 1944.—Supper and Social Evening at "Chapel Tavern," Great Charles Street, Birmingham, 3, commencing 6.30 p.m. Admission 4s. 6d. per head to members and one friend only, who should preferably have connections with the Plastics Industry. Application for tickets should be made direct to hon. secretary.

Saturday, October 7, 1944.—Dance at

Botanical Gardens, Edgbaston, Birmingham, 15, from 3.30-8.30 p.m. Jimmy Donovan and his " Radio " Band will play for dancing. Tickets are 5s. 6d. each direct from the hon. secretary.

Monday, October 9, 1944.—Joint meeting with the Institution of the Rubber Industry —Midland Section—at the James Watt Memorial Institute, Great Charles Street, Birmingham, 3, commencing at 7 p.m. Refreshments available from 6.30 p.m. G. Loasby, Esq. (British Nylon Spinners, Ltd.), will read a paper entitled " Nylon."

Friday, October 20, 1944.—Lecture meeting, commencing 6.30 p.m. at the James Watt Memorial Institute, Great Charles Street, Birmingham, 3, when a paper entitled " P.V.C." will be read by N. H. Chamberlain, Esq. (Celluloid, Ltd.). Refreshments available from 5.30 p.m.

Plastic Tail Lamp

The position of a tail lamp stipulates at least two mechanical properties, high impact strength and high resistance to vibration. These necessities resulted in the production of the well-known Rubbolite rubber tail lamps by Flexible Lamps, Ltd., of Ridge House, Forest Side, Epping, Essex.

With the coming of restrictions this company sought a material to replace rubber and found it in the most recently developed of high-impact-strength plastics.

The specimen lamp we have examined is a thoroughly well-made component with the main holder and cap moulded of " Rockite " 3932, the special phenol-formaldehyde string-filled resin which we described in our December, 1943, issue. It may be remembered that this resin product of Cellomold, Ltd., has an impact strength of 2.5-3.0 ft./lb., that is about 20 times that of an ordinary wood-flour-filled moulding.

The rear lamp in question is the first industrial moulding we have seen in this material and we congratulate Flexible Lamps, Ltd., on choosing it for the manufacture. Doubtless elasticity or resilience is highly desirable in such a lamp, but the high shock strength and resistance to vibration of the plastic now employed will give it long life.

The new tail-lamp of high shock resisting plastics made by Flexible Lamps, Ltd.

Planned Mould Maintenance Service Aids Economical Production

Part V

By W. M. HALLIDAY

In this article particular consideration is given to a number of interesting mould design and construction features of moulds employed in the Injection Process. Special note will be taken of the manner in which such features may promote or retard smooth operation and trouble-free service.

FOREGOING sections upon this subject appearing in previous issues have been devoted largely to the consideration of the many desirable and undesirable design features applicable to moulds employed in the compression method of moulding, specially observing their effects upon maintenance oversight duties and freedom from serious failure of breakdown. Numerous instances have been presented showing several ways in which conventional designs and types of mould construction may be adapted or modified so as to ensure a larger measure of reliable and sound working service when the mould is placed in production.

There is another very extensively used class of mould which so far has not been dealt with, it having been deemed advisable to defer all consideration of design, construction, and maintenance problems associated with its use for exclusive treatment in a later article. This type of mould is that employed under the injection process of producing moulded articles, where, by the very nature of this process, a different technique of mould design and application is necessary.

Several important reasons support the adoption of such exclusive consideration, such as, for example, the great diversity of mould designs in use or possible, and the entirely different principles underlying their manufacture and application, which, in turn, indirectly give rise to a different set of problems both for designer, mould engineer and especially the maintenance toolmaker.

Characteristic Differences Between Injection and Compression Moulds

Whilst injection moulding is by no means a new one, many users and would-be users of mouldings fail to appreciate the fundamental differences, possibilities and respective limitations of the two processes, a fact which in some cases is responsible for the evolution of very unsatisfactory mould constructions and indifferent service. This may often arise when the creator of the moulding design has little practical experience of injection mould manufacture, with all its connected snags, etc.

Injection moulding closely resembles the die-casting process of forming metallic articles. A steel mould is used, this being made in two main portions—one stationary, the other movable—so that the finished part can be removed conveniently. Thermoplastic substances are employed, as these readily soften by the application of heat and they flow easily at certain temperature ranges, whilst at atmospheric temperatures they solidify again.

The material is rendered plastic or fluid in a separate chamber and not within the moulds, as in compression moulding. It is then pumped or, rather, powerfully squirted into the split mould, whose halves have been suitably closed together and clamped powerfully shut, thereby excluding all escape of the material. The mould cavity is thus filled

with hot plastic under great pressure and it immediately begins to solidify upon contact with the relatively cool mould surfaces.

This rapid formation of the shaped product enables it to be ejected from the mould halves within a very short space of time after injection. There is thus no curing time in the sense understood in compression moulding practice, with additional advantages of a small amount of wear of mould surfaces, as the friction is very much less, due to the incoming plastic material being almost fluid. Extremely rapid production is also possible because of the comparatively short producing cycle and the immediate solidification of the plastic material.

From the particular angle of the mould maintenance engineer several important conditioning features are associated with injection-type moulds, due to the above-mentioned fundamental differences. These features are, in fact, of such a nature and magnitude as to place the injection mould into a class of its own. A very useful purpose will be served by listing out some of the chief of these features, as they afford a brief indication of the numerous maintenance points likely to be found under working conditions with such type of moulds.

These distinguishing features worthy of attention are:—

(1) On both design, mechanical construction, as well as in method of operation, injection moulds are generally of a much more complicated character than their prototypes in the compression method of moulding.

(2) Generally all necessary moulding opening and closing movements are performed by machine motion and, of course, automatically. Similarly with respect of core withdrawing means, or ejector rods or sleeves, these, too, are very often operated by purely mechanical means and so are caused to function positively and again automatically in complete unison with other normal machine movements.

All such movements usually are conducted at considerable speed, in contrast to those relating to similar purposes employed on the compression mould.

(3) Such moulds generally include very important auxiliary mechanisms for the withdrawal of core members, ejecting the finished part, locating and retaining non-plastic inserts, etc. Very often such apparatus is of a complicated design and construction, which in itself requires closer attention and foresight on the part of the designer when developing it, as well as from the maker who has to construct and maintain such mechanisms in sound working condition.

(4) Multi-impression moulds are very extensively employed in this process, which, again, is a factor conducive to increased mechanical complexity of mould design, etc., coupled with the corresponding need for added care and frequent inspection or observation during working life.

(5) Production is generally at much quicker rates than in compression moulding, due partly to elimination of curing and partly to quicker ejection, as well as more completely automatically operating moulds.

(6) By this method of moulding more intricately cored articles are possible. Similarly with regard to external configurations, here, again, more difficult shapes can be tackled successfully. Both these considerations very greatly affect design and construction features, and, in turn, the matter of the general upkeep and satisfactory maintenance of the mould in proper working condition.

(7) Much higher pressures are employed in this process, which, in its turn, demands a mould construction capable of withstanding such elevated pressures without undergoing drastic or serious distortion or dimensional alteration, not to mention the permanent fracture or damage of its component members.

From this necessarily brief outline of some of the main points of difference contained in the injection-type mould, it will be clear that there must be a greater

number of points having peculiar interest for the maintenance engineer charged with their care. As in all mechanical products, the greater the degree of intricacy of design and construction, the greater the number of possible sources of trouble, operating snags and misfunctioning.

Continuing the procedure of presentation adopted throughout the previously published sections, a number of practical injection mould designs, or portions thereof which are illustrative of some point under consideration, will be selected and considered in some detail in order to elicit the desirable and undesirable features. These examples have been selected as being typical mould constructions representing commonly encountered faults or design shortcomings, and thus can be regarded in the nature of guides to cover whole classes of mould designs.

Basic Elements of the Injection Mould

Before commencing a detailed consideration of individual mould examples, some misunderstandings may be avoided by first noticing the basic elements or fundamental mechanical components comprising any injection mould design, together with their respective functions and manner of operation.

By such a preliminary it will be possible for the prospective mould designer and manufacturer to derive a fresh appreciation of the purposes to be fulfilled by each individual mould component. Especially will this be a useful approach to maintenance problems for the would-be user of plastic mouldings who possesses little practical knowledge of mould design and construction.

By seeking such a better understanding of the basic elements of injection mould, much useful knowledge or appreciation may be gained regarding the effects of high pressures upon mould materials, smoothness of operation, and all essential working parts. The possible effects of temperature variations, results of continuous frictional contact between mating members, and the ability of the construction to resist distortion in vital points may also be more better understood and due provisions allowed when developing the design.

Lack of such close appreciation of the interaction of mould parts and the effects to be caused by working conditions may give rise to an unsatisfactory tool, which upon tact with normal working conditions may produce several troublesome maintenance problems.

In passing, it should be noted that much less has been written and discussed in the technical Press respecting the technique of injection moulding and particularly with reference to the underlying principles of injection mould designs and economical construction and use.

One reason for this evident dearth of up-to-date information on this type of mould may lie in the numerous and diverse sources from which developments have generally arisen. This may have resulted in a very spasmodic or indifferent degree of interchange of ideas and all essential knowledge which has accumulated as a result of many practical experiences and research.

The chief elements common to practically every injection mould are as follows:—

(1) Mould Blocks

Unlike presses used in compression moulding processes, injection moulding machines usually have a very restricted size limit covering the gap opening between the main tie rods, within which the whole mould assembly must be situated. For this reason an entirely different construction and operation procedure must be employed.

Then, again, the greatly increased moulding pressures not only entail extra stresses and strain upon all portions and component members of the mould, but also require the formation of a substantial set of mould blocks and a method of attaching them to shoes and machine platens in such a manner as will afford a sufficiently strong set-up capable of

withstanding these high pressures and stresses.

As is implied by their name, the mould blocks are the steel or steel alloy members into which the cavity forms necessary for forming the moulded article are cut. In a previous article mention has already been made of such important matters as choice of materials, suitable heat treatment, etc.

In addition, considerable other mechanical arrangements are incorporated in or upon the mould blocks, such as core withdrawing or locating means, facilities for guiding and operating ejector rods and so on.

It will thus be apparent that very considerable degrees of skilled labour and machining time are often expended upon the preparation of a set of mould blocks.

One block is usually regarded as stationary in that it is attached to the nozzle platen of the injection machine, whilst the movable mould block is secured to the moving platen guided along the main tie rods of machine.

Several methods of mould block construction are in common use at the present time, but the selection of any particular one of these methods is largely conditioned by the nature and extent of cavities required to be fashioned in the block, quantity of parts to be produced from the mould, degree of accuracy desired in respect of the finished product, and the complexity or simplicity of other mould components.

(2) Mould Shoes

These members are special blocks utilized to afford additional support, backing, and stiffness to the mould blocks proper and are particularly useful for the following reasons:—

(a) Where the mould blocks must necessarily have but thin cross-sectional portions and likely to suffer deflections when subjected to pressures during moulding operations, the shoes provide that extra support by imparting stiffness to such slender blocks.

(b) Correct alignments are maintained by their use.

(c) Another important purpose served by the mould shoes is to permit the wide application of standard methods of fixture of block to machine platens regardless of the overall dimensions of the blocks.

(d) Then, again, very often the rear faces of a set of mould blocks are very extensively drilled or contain a large number of screws, dowels, and the like so that little available space is left into which the standard bolt hole locations can be accommodated. By using a shoe plate, however, such troubles are avoided and standard fixing means can be utilized even with the most complicated tool construction.

(3) Cores—Fixed and Movable

Here, again, is another very vital feature of mould design. Cores of different shapes and widely differing sizes can be successfully used in injection moulds. It is possible to operate these automatically and simultaneously even when a number of cores are contained in the mould block.

All internal openings of a moulded article must be cored in some manner either by means of a fixed core member, with the finished article then being stripped from it. On the other hand, sliding core members may be used when holes have to be formed at right angles or out of parallel with the line of mould block parting. In such instances it is necessary for the sliding core to be operated before the main mould blocks commence to open or before ejection of the finished parts occurs.

(4) Ejector Mechanisms

As with cores, so with the means and provisions for ejecting the finished moulding very ingenious methods and mechanisms can be employed. Ejection can be by several means, such as by sliding ejecting rods, stripper sleeves, or plates. Their purpose is to effect the safe removal of the finished moulding from its cavity. Unless great care is exercised considerable difficulties and operating snags may arise due to faulty or unsatisfactory ejector arrangements, and thus they constitute

one of the most frequent sources of maintenance attention and care.

(5) Sprue

This is that portion of the mould in which is located the track along which the flowing plastic material passes after leaving the machine nozzle and prior to its entry into the mould block cavity.

(6) Runners and Gates

The runners are the channels along which the incoming material is guided from the sprue mould entrance to the respective feeding points known as gates, and thence into the cavities. The runner termination is usually restricted in size to form the gate. In injection moulds some troubles often arise in respect of both runners and their gates, such as best disposition of same, securing their most suitable sizes and dimensions, and judicious selection should be made in positioning and machining such runners, etc.

(7) Dowels and Guides

As in the case of compression moulds, dowels and guide pins play a very important part in affording and maintaining mould block alignments and continued accuracy. Other mould mechanisms also require dowelling to ensure retention of original setting, or to assist renewal when wear occurs. In view of the greater working pressures and working conditions generally the dowels assume greater importance in the case of the injection mould, but it is not proposed to add anything further to that which has already been written and published in previous sections.

Mould-block Constructions

Reverting back again to the question of mould blocks, the question of their method of construction plays a very important part in subsequent satisfactory working.

By far the most widely used method of block manufacture is that which employs a pair of solid-steel blocks suitably bedded together so as to seal closely. Into the mating surface of each block the requisite cavity is cut out of solid material by one of the common types of machining but cutting tool. Thus, the cavity may be machined either by straightforward boring in a lathe, or by milling machine, or cut out by die-sinking processes on the special die-sinking machine, or again could be milled out by means of the pantographic milling machine using suitable master forms.

Such machining methods are widely understood, and the skilled labour is available for its performance. Then again, the method offers the simplest and, perhaps, the safest, way to form the cavity. It may not prove the least expensive or the most reliable method when a multi-impression mould has to be made, and where the cavities must be exactly identical in size working to very close limits of error, then again some difficulties may be encountered by this method.

From the point of view of the mould-maintenance service it must always be borne in mind that generally large quantities of stock are removed from each mould block, and, in roughing stages at least, where the bulk of material is removed, stresses may be imposed upon the remaining block material which might give rise to troubles later on when the block is undergoing heat treatment, or when it is finally placed into service on the injection machine.

A second method of forming the necessary cavity or cavities in the mould blocks is to sink them into a solid block by means of a specially made hobbing tool. This tool is made up with a contour and exterior dimensions an exact duplicate of the part to be moulded, plus, of course, a small amount to allow for shrinkages of both mould and moulding material upon cooling. This hobbing tool is then forced into the mould block under great pressure so as to effect a gradual displacement of the material to form the requisite cavity shape.

When the hob has been fed to the required depth the cavity will then be an exact duplicate, but in reverse, of course, and the surfaces of the cavity will have

a high degree of polish because of the absence of any tooling or tool-feeding marks as is unavoidable when using one of the ordinary cutting methods.

Certain manufacturing difficulties are connected with this process of cavity formation and to perform it successfully requires considerable skill and extensive practical experience, which, as yet, are not widely possessed by toolmakers and mould engineers. This may be one of the reasons why toolmakers generally tend to look askance or with some distrust on this method.

Unless hobbing is performed with this skill and understanding, not only may there be failure to utilize the best advantages possible to the method, but serious maintenance difficulties may eventually arise when the mould is placed into service.

But successful cavity formation is possible by those fully conversant with all the practical needs involved by this method of cavity hobbing, and not only are economies possible in the way of subsequent mould surface finishing, but also exact duplication of cavity shape and size is more readily possible than by cutting methods.

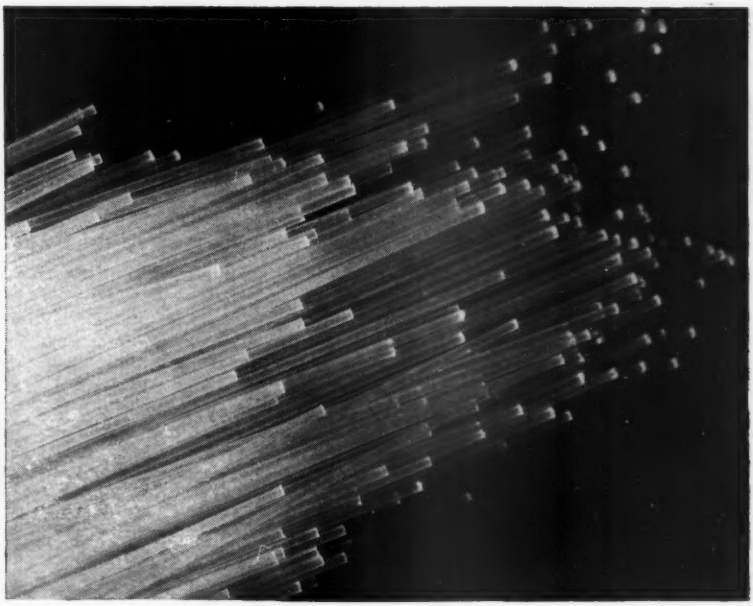
Another widely used method is that which employs separate steel insertion pieces let into the mould blocks and secured thereto in a suitable fashion so as to form what is, to all intents and purposes, a solid mould block. Either the entire cavity or main portions of it are previously machined in or upon these insertion blocks prior to fixing in main blocks. This method often permits substantial machining economies, and also greatly simplifies those operations. In addition, very awkward or unusual shapes of cavity may be formed in such insertion blocks, which would not be possible when using solid blocks. This is readily understood when, say, it is required to form an accurate threaded portion in a difficult or inaccessible location. Or, if undercut or stepped portions are required, it may often be practicable to use such insertion blocks rather than attempt to cut the cavity straight into the mould blocks.

Sometimes the mould blocks may be built up from a number of small blocks or plates to form a composite block, and no doubt isolated instances arise from time to time which necessitate such a method of mould-block assembly in order to secure the required cavity. But innumerable difficulties are apt to develop, and very extensive maintenance attention be called for, when such a mould is finally placed into production.

Especial consideration will be needed when employing such composite type of blocks because it will be difficult effectively to build together a number of strips or plates or sub-blocks into a single block without troublesome joints. There will, of necessity, have to be a large number of dowels, pins, rivets, retaining screws and the like, and these will only have a limited degree of tightness, which may allow a slackening off when the mould is heated or stressed by heavy pressures or subjected to rough handling during use.

In addition, these members are prone to expand and contract unequally and at different rates from each other and from that of the major portions. This will cause some opening of the joints and these, in turn, will become the source of some trouble by allowing plastic material to find access and so cause a sticking or hanging of the finished moulding. Or dirt or lubricant may find lodgment in such cracks or openings to cause extra cleaning operations. Furthermore, it is necessary to remember that such slackening of the composing strips may also cause some stiffening of the passage of core rods, pins for ejections, etc., which have to move within holes drilled through two or more strips.

East mould block, whether built-up or solid, must be provided with a sealing face or "land" surrounding the cavity, and here, again, in this connection in the case of injection moulds additional care will be necessary in determining the position of cavities and other mould components, so that a uniform and adequate land is left after all other machining operations have been conducted. These



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lands are ground and lapped to form a very close seal when mould blocks are closed together in the locked position. Thus all escape of material is prevented, flash is kept at a minimum and sounder mouldings result.

Cavities should be arranged within the mould blocks as symmetrically as possible relative to the sprue, so that runner length can be kept uniform, thereby ensuring that equalized feeding of cavities is secured and that there is a uniform pressure upon various parts of mould blocks. Thus strains will be lessened, distortion avoided to a great extent, and the risks of stiff working or even seizure of parts obviated.

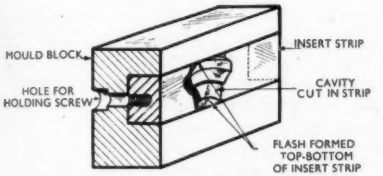


Fig. 1.—Simple mould design for knob moulding.

In general practice it will be found that the best policy is to sink or machine the cavities, etc., into solid blocks rather than to build-up the latter. If, however, composite or built-up blocks have to be used all jointing lines of any insert blocks or strips, etc., should coincide as near as possible with the edges of the moulded article. If this is not practicable, then the jointing lines should be positioned so as to lie along unimportant edges or across non-essential dimensional points.

All joints should preferably be in the same plane as that of ejection and not at right angles to it. All strips or insertion blocks should be well bedded down to ensure very close fitting so that no tiny gaps are left into which material may be squeezed. Joints should, of course, be located well away from the cavities or points where material passes from sprue to cavity. Where possible joints should not lie across the sprue entrance or passage otherwise they will cause interference when pulling out the waste sprue material, as the material will be forced into any cracks caused by a joint and will have to be severed through before the sprue can be pulled out.

In Fig. 1 is shown a small sectional cut-out of a portion of a mould block which is of simple design for a knob-like moulding. It will be noted from this illustration that the main block is provided with a rectangular slot on its front face extending clean along full length. This slot is cut fairly deep into the block and, of course, is made exactly parallel in width. Into this slot is fitted tightly a rectangular-shaped strip held by means of socket-head retaining screws passed through from the back of the main block, as shown. The strip is machined to form exactly half of the full cavity, the remaining half, of course, being similarly formed in an identical strip attached to the other mould block.

In this actual example only one cavity is shown.

It will be specially noticed that this strip is made the same thickness and has the height of the finished cavity, this latter passing clean out the top and bottom sides of the strip. The sides of the slot in the mould block serve then to seal off the top and bottom sides of the cavity when the strip is secured in place.

This form of construction enables the cavity to be made with perfectly square corners at top and bottom edges, which would be somewhat difficult by other machining methods upon a solid block and, in addition, manufacture would be simplified. The two strips would be machined together so far as cavity formation is concerned, either being bored out in the lathe or milling machine. The strips would be previously surface ground up to correct size and then clamped together tightly whilst milling the cavities.

But from the angle of possible trouble it is open to several drawbacks, chief of which are as follows:

(a) It will be extremely difficult so to fit the cavity bearing strips into the main blocks as will effect complete sealing off of the cavity ends *without*

some flash formation occurring either initially or after very short running. This will result in a slightly open jointing point top and bottom of the cavity, which, in its turn, will entail some flash formation and sticking of the moulded article, with repeated shut-down of mould in order to clean out adhering particles of plastic material and efforts to close up the crack.

(b) Under working conditions such flash will tend to worsen, especially so if the main block becomes distorted due to heat or pressure conditions.

(c) It must be remembered that such a strip when originally fitted to the new unworked mould may appear a good workmanlike job. But the different and often severe circumstances encountered when the mould is placed into service may cause either a slight loosening of the strip due to stretching of retaining screws or a disturbance in their lock. If this should occur the strip may become slightly advanced in its slot in the main block sufficient to prevent the complete closure and sealing of the two halves of the mould when in moulding position. Thus additional parting-line flash would develop after a time, with the consequent need for removing the mould at intervals in order to tighten up and clean the strip member.

(d) Yet another very possible source of trouble which would be associated with a mould block of this construction concerns the fitment of ejector pins, guide pillars and, indeed, any mould component which must slide through cross-located holes passing through both the main block and insert strip portions. Any disturbance of this latter piece may cause the stiffer working or even complete seizure or inability to move of such pins, etc., due to slight misalignments caused by the shifted strip. So here, again, the maintenance toolmaker would be confronted with the necessity for very frequent examination of the mould and fairly frequent removal of the mould from the machine in order to effect correction of such undesirable developments.

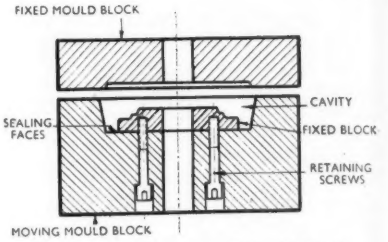


Fig. 2.—Common type of mould block.

It is perhaps true that such a type of mould construction might prove satisfactory or even economical if only a very small quantity of parts are to be moulded. But if a substantial run is required then trouble would probably arise as to render the use of such a mould construction very disadvantageous and certainly costly from the point of view of maintenance services.

Where possible, then, in the case of medium or large-batch orders it would be advisable to sink the cavity directly into a solid block by making up special tools for the purpose. The appended illustration in Fig. 1 will serve to indicate some of the pitfalls present in even one of the simplest constructions.

Another very common type of mould block build-up is illustrated in Fig. 2. This shows a sectional view of the fixed

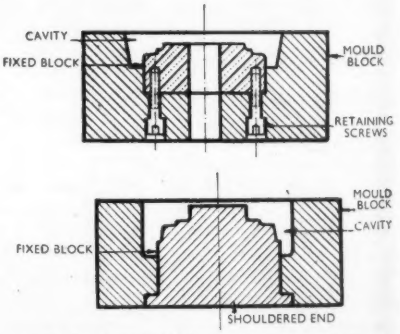


Fig. 3.—Improved forms of mould blocks.

and movable mould block. Into the latter the main portion of the required cavity is cut, which, in this case, is in the form of a circular or, rather, conical piece having a stepped recess in one side. This stepped recess portion is formed by the insertion of a small block fixed to the flat bottom face of the cavity, as shown. This insert piece is simply bedded down carefully and snugly and held by means of a number of retaining screws passing clean through the moving block. Thus assembled, the insert, in effect, becomes equivalent to a solid block, or so it is intended.

Here, again, whilst this is a construction offering some degree of simplicity and cheapness so far as manufacture is concerned it is not one to be preferred on account of the following drawbacks:—

(e) The jointing faces formed between fixed insert and cavity base seal-up at right angles to the line of normal ejection. This will result in a small flash being formed around this joint, which flash will have to be severed each time before the completed moulding can be withdrawn. Where the insertion piece is fairly large its perimeter distance may be considerable, which will mean that a large area of flash is present, all of which will have to be cut through before ejection can take place.

(f) It will also be somewhat difficult to effect an absolutely close-fitting joint at this point initially, and certainly it will be difficult to maintain even the original close sealing of the joint.

(g) The normal working of the mould together with the contractive grip imposed on the sides of the insert block by the rapidly cooling moulding will tend to lift the insert piece at each ejection, which, in time, may cause a stretching of the retaining screws, especially if these are of slender diameter or long length. Thus the insert may became loosened and disturbed and a greater gap formed between its bottom edge and cavity base, this, in its turn, causing increased flash on the moulded article.

Two considerably improved forms of mould block formation are shown in Fig. 3, which illustrate in each case the sectional view of the movable mould block only.

Dealing first with the upper view, which is of a similar mould for a tapered circular moulding, it will be seen that the insertion block is situated in a suitable recessed portion machined in the bottom face of the cavity. It is made a tight press-in fit therein and is additionally secured against pulling out by a number of socket-head retaining screws passing in from the opposite side of the main block, as shown. Dowels are not required to ensure correct location of this insert as it is retained correctly by the method of fixture.

From the maintenance point of view this construction possesses several worthwhile advantages which are as follow:—

(h) First, any flash which may be formed on the finished moulding due to a slight gap at the juncture of the insert side and wall of recess will be vertical and in the same plane as that of the movement of the ejected part. Thus there will be no necessity for the severance of the flash at each ejection stroke.

(i) In most cases should the retaining screws become loosened little harm would be done to the mould as the insert block is sunk sufficiently deep into the cavity base portion to allow for any slight forward movement caused by slackened screws. Such movement would be noticeable and perhaps harmful on the moulding, but no additional gap for the lodgment of material or the formation of thick flash would be caused.

(j) If required, shim-stock could be inserted under the insertion block in order to raise it any slight amount desired, such as by a small change in moulding design, or a modification of some size. In the case of the construction shown in Fig. 2, this would not be

possible, and a new insert block may have to be provided.

(k) As the exterior of the insert block and sides of recess in main block can both be accurately bored and ground to extremely fine limits, a very close and tight-fitting joint may be made without great expense or trouble. This is worth while comparing with the time usually absorbed when such inserts have to be hand fitted and bedded down in place by protracted and correspondingly costly hand-machining operations, such as scraping or lapping.

The lower view shown in Fig. 3 illustrates yet another very useful and reliable type of mould-block construction. It will be noted that the main portion of the cavity is formed in the moving mould block half, and this member has an insertion block let into it in order to form the requisite shape on the internal surfaces of the part being moulded. This fixed insert block is fitted tightly into a plain parallel bored-out hole machined through main block as shown. At its bottom end this insert piece is provided with a circular flanged head, which portion is housed in a suitable machined recess in block. The extreme end of this shoulder lies exactly flush with the rear face of main mould block. This shoulder serves to locate the insert block and controls the extent of its projection into the mould cavity area. Screws could be employed if desired to restrain this insert block from being pushed back under pressure of the incoming material during injection, and they could well be situated through the flanged portion of insert and passing into tapped holes provided in body of main block. This is not here indicated, however, for reasons of clarity.

As an alternative method to prevent the insert piece from being disturbed, care may be taken to ensure that the end face of the shouldered portion finishes off flush with main mould block in order that the mould shoe fitted later will bear on top of shoulder and thus prevent any movement of insert out of main block.

Should any adjustment in the amount of projection of this insertion piece into cavity be required, such alteration would be readily obtainable by the simple expedient of inserting a packing shim between shoulder of insert and bottom face of recess in block so as to withdraw the insert slightly out of cavity. If, on the other hand, it is required to advance it further into the cavity, then it will be a very simple and quick matter to remove a slight amount of material from the underside of the shouldered end of insert piece.

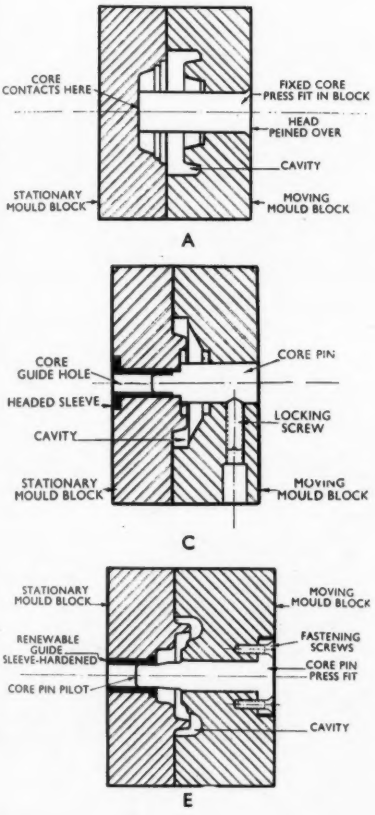
Many more similar interesting examples could be given showing variations of these simple constructions, but space considerations forbid any further mention being made here of this aspect of mould design, etc. Enough will have been discussed, however, to afford a good indication of some of the general features to be aimed at, and the kind of mould-block constructions which is most likely to give rise to operating troubles with increased maintenance oversight.

Design and Assembly of Fixed Cores

As already described earlier, injection moulds for producing plastic articles of very simple shape may comprise only two members, viz., the mould-block halves. The cavity formation may be contained entirely in one block, or a portion in each block as desired.

In the majority of moulding designs, however, some coring is necessary in order to provide for openings, holes or slots in the finished product. To accomplish this, additional mould elements will be required in the mould. Depending upon the position and shape of such cored portions, the requisite core members of the mould may either be fixed or movable. In the case of fixed cores, these will be so attached to the mould block or blocks or to an auxiliary stationary plate as to amount to a permanent non-moving portion of the mould.

In the case of withdrawable core members, these usually are so mounted as to slide within suitable guide holes formed in the body of the main mould blocks or



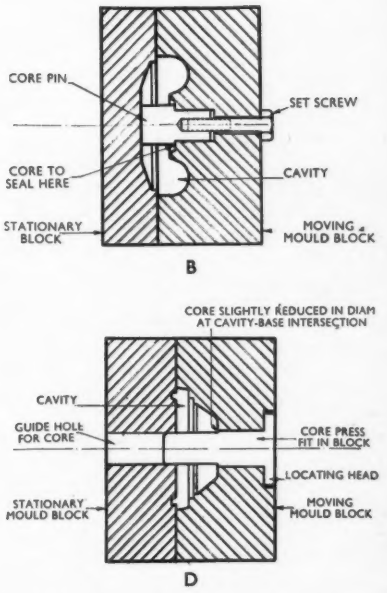


Fig. 4.—Five methods of core-pin retention.

within sleeves or a core plate attached securely to the mould block.

The stationary or fixed cores are required in cases where very excessive amounts of mould block material or labour would be required to make up the mould. Only in instances where the accuracy and surface finish of the final product would be affected should the projecting portions of the mould block be machined out of the solid piece.

Experience has shown that much of the maintenance and operating trouble encountered in respect of fixed core members relates to the method of fixture within the main mould blocks and, apart from this aspect of their application, little else need be mentioned.

Five different methods of core-pin retention are here illustrated as A to E in Fig. 4. These will indicate the various unsuitable and preferable types of fixture which the writer recommends to the consideration of readers.

Each of these illustrations is a sectioned cut of a pair of mould blocks with cavity formations of slightly different shape. Referring to the first one shown at A, this consists of a plain cylindrical core pin which is pressed tightly into a plain bored hole formed in the moving mould block. A portion of the cavity is provided in each mould block, as will be seen, and when these members are brought together into the moulding position the end face of the fixed core pin bears down upon the bottom face of the shallow cavity recess formed in the stationary block, so as to effect a sealing off for the flowing material. Thus the

moulded article will be produced with a hole clean through.

Of special interest to the maintenance toolmaker is the method employed for retaining the fixed core pin in correct position within the main block. It is made a tight press-in fit in its hole, and when in place a short portion of pin projects over the right-hand end face of the mould block, sufficient to allow it being peened or riveted over, as shown. The edge of the hole in the mould block is, of course, countersunk a short distance to accommodate this riveted head.

Now, this method of fixing is undoubtedly very inexpensive, but will certainly prove very unreliable when placed under working conditions, for the following reasons:—

The upset head portion will not add to the tightness of fit between the core pin and main block, and, moreover, will only prevent endwise movement of the core pin in one direction—that is, the core cannot be pulled forward within the mould block cavity. But this is not a vital point in comparison with the need for preventing the core pin from pushing back out of the cavity and so leaving a gap between its end face and the base of the cavity recess in the stationary mould block. Should this occur, the finished moulding would have one end of its internal hole blanked up by a flash, which, in some instances, may well be of considerable thickness; this, in turn, would entail additional trimming activities for its removal. Such an operation might also incur the formation of an unsightly scar at the end of hole.

Then, again, should the plain cylindrical hole in the moving mould block in which the fixed core pin is to be situated be only of short length, the act of upsetting the core-pin head may cause a misalignment of the pin itself, throwing it slightly out of square with the parting line faces of mould blocks. If this should take place, then serious sticking troubles would be encountered when ejecting the finished moulding, and not only would this operation be considerably slowed up, but also the bore of the moulded component may get badly scored or even distorted so as to render the part unsatisfactory.

Altogether, even making every allowance for the simplicity and low cost of manufacture of this type of core-pin fixture, it is one to be avoided so far as possible, as it is likely to give rise to repeated snags and objections. And it must be remembered that the initial low cost of installation is not the true cost of the part. To this must be added any after service entailed by the member failing to operate satisfactorily when placed under working conditions.

The second illustration shown at B is another commonly used method of core-pin retention, and is certainly an improvement upon the design A, already dealt with.

Here, again, each mould block contains a portion of the cavity, and the core pin is of the stepped type, the smaller diametered portion being fitted tightly into a plain bore hole in the movable mould block. The larger portion projecting into the mould cavity is just long enough to bear down on the base of the cavity in the stationary block, as shown. The core pin itself is retained in position by means of the small set screw passing through the reduced hole in the movable block, and it screws into a blind threaded hole provided in the end of the core. The set screw pulls the core pin back against the shoulder and the bottom of the cavity.

The advantages of this type of fixture are obvious, as the core pin is properly fixed and restrained from endwise movement in either direction. A positive lock is obtainable since the pin is shouldered. It is also very easy to manufacture, and, with reasonable care and fairly frequent inspection, will give good service.

It is only fair to point out one or two disadvantages possessed by the design, however. Thus the length of the larger-diametered portion of the core pin must be dead the same length as the depth of the cavity; otherwise, if it is slightly shorter, then the moulding will exhibit a flash at one end of its hole, or, on the

other hand, if the pin is too long, the two mould blocks cannot be completely closed, whereupon the finished products will have a flash around the mould-block parting line, and, of course, all thickness dimensions will be too large. In addition, there may be the danger of such a wide gap occurring as will cause a harmful escape of plastic material along the parting of blocks. Furthermore, unless the operator maintains the mould cavities perfectly clean there may be the danger of an accumulation of plastic particles adhering on the end face of core pin which will prevent it from seating down correctly on base of stationary mould-block cavity, resulting again in flash formation.

Another point worthy of attention concerns the set screw used for retaining this core in place. If this is of long length, say more than about eight times its diameter, stretching may occur due to temperature of mould during working. This would allow the core pin to work loose during actual injection of material and any slackness thus present would offer opportunities for the creation of flash.

In servicing a mould construction of this type the maintenance toolmaker would have to check the degree of lock imparted by this screw, and also to examine where particles of excess plastic material had found lodgment on end face, or at the juncture of pin shoulder and bottom of cavity in moving block. The squared end face of the core pin adjacent to the cavity base would also have to be checked for absence of burrs, scratches, or wear. Repeated extraction of the finished moulding may cause the sharp corner on end of core to be worn slightly, which, again, would cause a slight depression being formed in cored hole in the moulded piece.

The illustrated construction shown at C is again not quite satisfactory, especially in respect of the method by which the fixed core pin is retained in moving mould block. The core pin shank is perfectly plain and cylindrical, of course, and is made a press fit within the plain hole bored in base of the cavity in the moving mould block. A locking screw is situated in the block and engages with a dimple or recess cut in side of core pin as shown. Thus the pin is prevented from endwise movement. The forward end of the core is reduced in diameter and made a close sliding fit within the guide hole machined in the stationary block. This hole, it will be noted, is provided with a hardened and shouldered guide sleeve, the bore of which is ground out to allow the reduced end of core to be a sliding fit. The sleeve does not pass right up to the base wall of the cavity in stationary block as indicated, in order to obviate the formation of a flash line on the finished article.

This construction may cause certain troubles of a similar kind to those associated with the previously described types of fixture. Should the locking screw become slackened off for any reason then there will be a danger of the core pin being pushed back out of cavity, leaving a gap for the formation of extra flash at the base of cavity portion in stationary block. It could be improved in this respect by providing the core pin with a head situated in a slight recess in rear face of the moving block. Or the end face of core should be finished off exactly level with face of block so that when the flat mould shoe is fitted it will be impossible for the core to push back out of cavity.

At D is shown a much-preferred type of construction. Here again the bulk of the cavity is situated in the movable mould block as shown, and the core pin is made with an enlarged head at its right-hand end which is located in a shallow recess in block. The head finishes off dead level with face of mould block. The portion of the core used for forming the hole in the finished moulded component is extended so as to pass a short distance in the matching hole machined in stationary mould block.

Several important improvements are to be noted in respect of this design. As the end of core pin is passed into the stationary block no great harm will be done should the pin inadvertently become misplaced a slight amount in respect of its

correct endwise position. The head portion will bear against the mating surface of the mould shoe which will assist greatly in avoiding such endwise movement.

Another very useful point to be observed is the slight shoulder formed on core pin at the point where it enters the mould cavity in the moving block. Any alteration in endwise position will thus become apparent on the finished moulding by the presence of a slight, raised flash on right end face of the piece.

The possible points of trouble in connection with this design relate to the degree of wear likely to occur between the guide hole in stationary block and the end portion of core pin which passes therein. In the case of small-batch production this may not prove important, but where large quantities have to be produced then the maintenance engineer should afford regular inspection and test to both bore of hole and diameter of pin at this point to ensure freedom from wear. Should wear take place increased flash will result on the left-hand end of the finished moulding. The surfaces of guide hole and end of core pin must be maintained well polished and perfectly smooth, as any roughness may cause a stiffness in working, and ultimately binding action of sufficient degree as to force out the core pin when mould blocks are being closed. Only the tiniest speck of lubricant may, of course, be applied at this point due to the need for isolating oils, etc., from contact with the cavity surfaces and the incoming plastic material. The end of core pin should, of course, be hardened and ground and preferably lapped into position in the hardened hole in stationary block.

A very useful and reliable form of construction is shown at E in Fig. 4. Here again each mould block contains portions of the cavity, whilst the moulded article has to have a tapered hole up centre, this being formed for a conical portion of the fixed core pin. Again the core pin is provided with an enlarged head situated in a suitable recessed portion on rear face of moving block. Two or more vee-head fastening screws are utilized for securing this core in place. The forward end of the core is passed into the guide hole in the stationary block, the hole being bushed with a hardened sleeve. This member, it will be seen, is shouldered at the inner end, a recess being bored in the bottom of the mould cavity. The sleeve is located in such manner that the right-hand end face of part is brought flush with the base wall of cavity in stationary block.

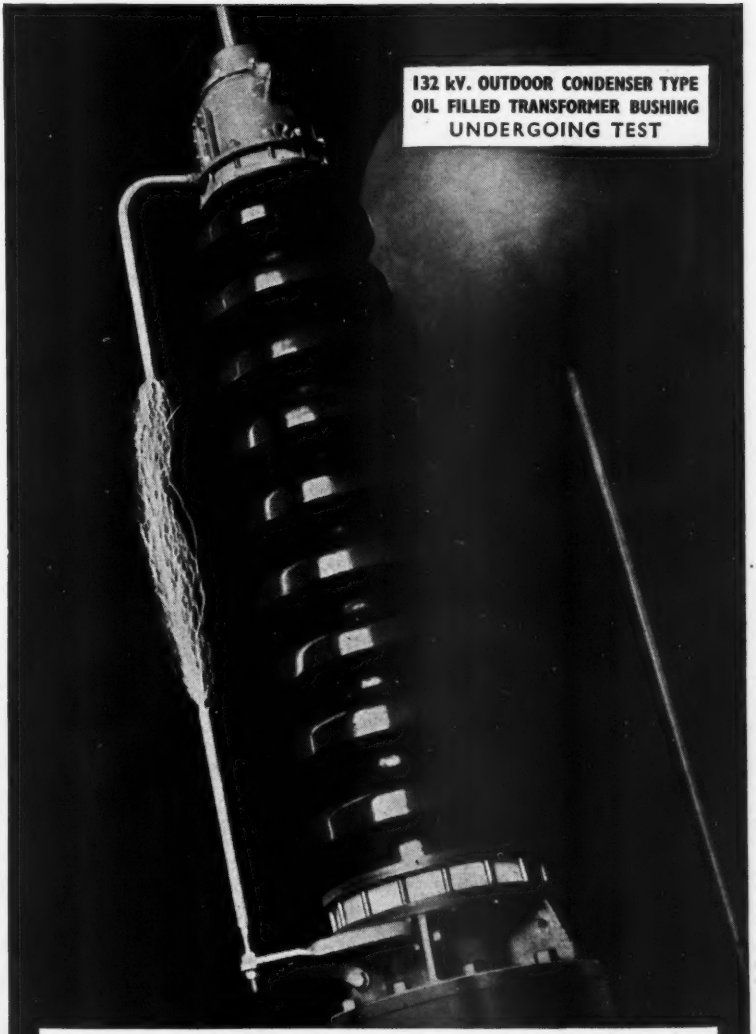
At the point of intersection where core pin enters the mould cavity, there is left a slight shoulder formed exactly in line with base surface of the cavity.

This form of construction, whilst admittedly rather more costly to produce, is certainly far more reliable and trouble-free in production, and can be depended upon to give good and prolonged service without the need for any appreciable maintenance attention.

In those cases where the finished moulding has to have cored holes of non-circular cross-section, especially when of small dimensions, considerable trouble is often encountered in their use by making according to the design shown in F, Fig. 5. Here, it will be seen, is illustrated a core pin of hexagonal shape. The hole in the mould block in which this core is to be seated must be similarly hexagonal shape. This method involves considerable trouble in machining, and fitting, and subsequent sealing off against possible flash formation. It is secured in position by means of the peened over head as shown.

A much-preferred method is shown at G, and this will prove far more economical as regards manufacturing and labour costs generally, as the machining operations will be very substantially simplified. It will also be more easily possible to ensure correct or accurate location and fitment of such core pins.

This core pin, it will be seen, has a plain cylindrical shank portion whereby the pin is fitted to the mould block, a plain bored hole only being required in this latter part. The core is only brought to the necessary shape, hexagonal in this



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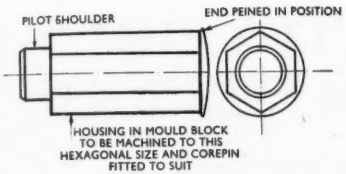
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HOUSING IN MOULD BLOCK TO BE MACHINED TO THIS HEXAGONAL SIZE AND COREPIN FITTED TO SUIT
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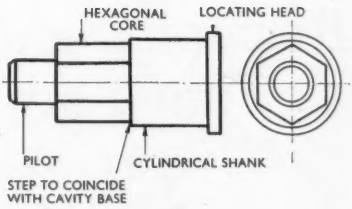

Fig. 5 (above).—Hexagonal core-pin. (Right) Showing a preferred construction.

instance, beyond the point of intersection with the mould-block cavity. The core-pin also is provided with a circular pilot portion for engagement with a guide hole in the mating mould block.

By adopting this method the holes in the mould block may be jig-bored, or precision drilled, and the cylindrical shank of the core-pin ensures that the subsequent fitting operations can be performed far more easily and with greater accuracy, and with practically no evident jointing crack into which plastic material may be pumped during injection, so giving rise to flash.

These examples indicate some common methods of fixed core retention and possible sources of trouble, but are by no means exhaustive of types of construction now in use.

INCREASING PRODUCTION WITH SYNTHETIC ADHESIVES

(Continued from page 416)

and the input power required is 600 watts. Other electrode assemblies have been developed to enable the transmitter to be used in preheating plastics prior to moulding.

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Chemical Research on Natural Fibres

Radical new developments in the chemical treatment of fibres which will have a profound effect on the post-war textile industry are announced by Monsanto Chemical Company.

As a result of long research in its Dayton and Boston laboratories dealing with chemical treatment of natural fibres, the company announced that its accomplishments to date include:—

Treatment of wool so that it will not shrink.

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Treatment of wool so that it creases under steam and heat, and then creases durably. Thus, trousers or suits that are pressed will retain the crease even in rain and will not wrinkle when packed into a suitcase.

Treatment of fibres so they will not slip. This means that stockings will not run nor seams pull out.

All of these developments, it was announced, are based on new techniques of treating either the surface or the heart of fibres to produce the desired effect without in any way changing the feel or texture of the material. In some cases the treatment involves the deposit of a submicroscopic film of plastics. In the case of the elimination of runs in stockings, the treatment involves the deposit of silica or submicroscopic grains of sand, which prevents the fibres from slipping out of the positions.

Part of a long-range research programme into the chemical treatment of textiles, the results up to now include greatly increased water-repellant qualities for cottons and rayons and increased fastness to washing or dry-cleaning through impregnation with chemicals which are highly resistant to heat, water and acid.

Resinoids and Other Plastics as Film Formers

By B. J. BRAJNIKOFF,
Consulting Electrical Engineer

XXIV.—Synthetic Coatings on Acetylene Base

IN Section II on plastics syntheses in relation to raw materials we dealt with acetylene as a fertile source of chemical derivatives, whose range and ramifications are of vital significance for the entire coating industry. As a concrete example illustrating this point, we outlined in Section V a series of relevant syntheses of valuable film-forming compositions as embodied in researches of the Russian Academy of Sciences and carried out since 1935 by its Institute of Organic Chemistry at a specially equipped laboratory of high molecular compounds in Moscow, under the guidance of the eminent savant Favorsky.

The investigations of the above institute comprise the syntheses of the primary vinyl ethers and their transformations. The object of this work, under the direction of Professor Shostakovsky, was to study unsaturated compounds which possess the ability for catalytic polymerization and are readily available as a raw material. A method has been developed for the production of simple vinyl ethers with yields from 95 per cent. to 98 per cent., as well as acetaldehyde, by means of hydrolysis of alkylvinyl ethers, under the influence of dilute acids. It has been found that, under certain well-defined conditions, hydrolysis progresses quite smoothly, yielding acetaldehyde up to 100 per cent. of the theoretical. The method evolves from Favorsky's studies and is based on the interaction of acetylene, divinylacetylene and other compounds containing a triple bond, with substances having in their structure one or several free hydroxyl groups. It has been established that the strength properties, transparency, frost-stability and adhesive power of polymeric products derived from the primary vinyl ethers, in particular of alkylvinyl ethers, ensure their extensive utilization in industry.

Nazaroff has also studied the connection between the structure of organic compounds and their ability for polymerization. There have been developed a number of the new polymerizable substances of the vinylacetylene series. Addition and condensation reactions, as well as the isomeric transformations in a series of acetylene and vinylacetylene derivatives, which represent the most important and typical reactions in the chemistry of unsaturated combinations generally, and for acetylene in particular, have also been examined.

These works, which, apart from their great theoretical significance, open up entirely new possibilities for applications of polymerizable substances in technology, have already demonstrated their value in aircraft construction, sea and land transport, chemical and electrical engineering, and other branches of industrial practice in Russia, where they gain an ever-increasing recognition.

Before we pass to the detailed discussion of the new film-forming agents as evolved by the Favorsky school, it may perhaps be helpful at this juncture to glance into the general development of organic chemistry in Russia which led to the striking results in this field.

Recent Developments in Organic Chemistry in the U.S.S.R.

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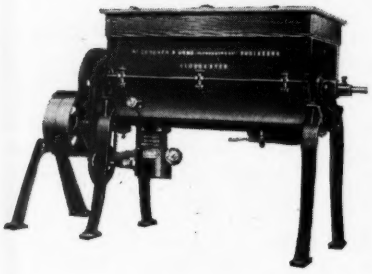

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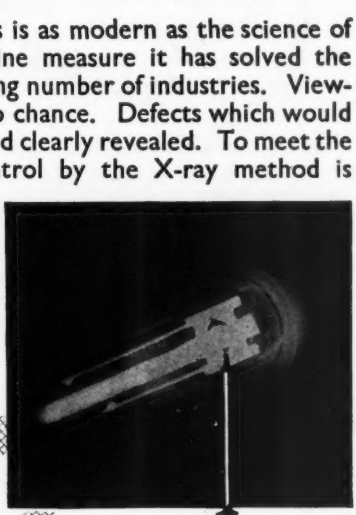

Radiograph of moulded assembly showing incorrect location of metal insert.

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branches of organic chemistry encompassed by the works of Russian chemists; (b) the effective participation of Russian chemists in the solution of the fundamental problems confronted by world science; and (c) the practical purposefulness of the work conjugated with their basic theoretical aspects.

The source of much of the work accomplished during the past 25 years should be sought in that wealth which has been accumulated from previous decades by the leading Russian scientific schools of organic chemistry, originating from the eminent Russian chemists of the 19th century: A. A. Voskresensky (1809-1880), N. N. Zinin (1812-1880), V. A. Markovnikoff (1838-1904), E. E. Wagner (1849-1903), and particularly A. M. Butleroff (1828-1886), who combined in the highest degree the unrivalled experimental art with the theoretical attitude.

The inheritance of scientific thought is inevitable and fruitful, as chemistry is an experimental science, the new nuclei of scientific activity arising through the branching of old laboratories that have accumulated a rich scientific experience, investigational technique, a fund of unpublished information, and, finally, the laboratory equipment fitted for the kind of researches characteristic to the nature of one or another scientific school.

Theoretical Aspects

The work of Butleroff and his students since the 'sixties of the last century on isomeric transformations in various classes of organic combinations has introduced many important concepts, which greatly helped to substantiate and expand the modern theory of structure, valency, chemical affinity, bonds and the mechanics of reactions. The investigations of isomeric transformations conducted by the Russian chemists for a number of decades have shed a considerable amount of light on the nature of chemical affinity as well as on single, double and triple bonds.

Of special interest are the views on the strength of chemical bonds in the light of the tension theory resulting from Favorsky's work of the past 25 years. Parallel with isomeric transformations enriching science with data on the comparative stability of molecules, and regularities governing these reconstructions, of equal importance are the phenomena of tautomerism and isomeric equilibrium.

Favorsky was able to forecast new interesting reactions by making resort to his fruitful schemes for examining the mechanism of reactions. Thus, he interpreted many such transformations as far back as 1895 in his doctorate thesis devoted to this subject. This work, as well as his dissertation devoted to the isomeric transformations of acetylene hydrocarbons, may be regarded as the cornerstone of all subsequent prolific studies by his school.

The consideration of reactions in organic chemistry in the light of the electronic theory is gaining, although somewhat slowly, a greater recognition, because of the systematic researches of the Academicians Pisarjevsky and Berkenheim, pioneers in the development of electronic concepts in application to the mechanism of chemical reactions, as has already been expounded earlier in Section XIV. So far the electronic theory has made only the first steps in the domain of organic chemistry; however, in the light of electronic notions many reactions find excellent interpretation, particularly in respect to reactions of isomeric transformations. Thus, according to the concepts of electronic theory, the polarity inherent to molecules may be explained by the different degrees of doubletting of the valency electrons; as a measure of the molecular polarization the degree of electronic mobility may serve.

The problems of chemistry in space and optical and geometrical isomerism have also been reflected in the original developmental works of Russian chemists.

Catalysis

In modern organic chemistry catalysis has found a universal application, particularly the use of the heterogeneous catalysis by means of which synthetic chemistry in the laboratory as well as on

an industrial scale has achieved striking results. The catalytic aspects of organic chemistry have been fruitfully exploited in Russia in specialized organizations built for this purpose, such as the Institute for High-pressure Reactions and the Plastics Research Institute, both at Leningrad, and others, with a large number of accomplished works on hydrogenation of glycols, alcohols and hydrocarbons of the acetylene series. In this respect particularly notable results have been attained by the investigations carried out at the laboratories of Academician N. D. Zelinsky, who has devoted a great deal of attention to the basic questions of catalysis.

The motivating forces of the catalytic action are the processes of change in the form of the molecule (deformation) under the influence of a catalyzing substance. The fatigue of catalysts is interpreted as being due to the modification of the molecular shape, which has been carried too far. The molecular form is bound to play the primary role in the process of catalysis, since there exists an intimate connection between the shape of the molecules and their ability for catalytic transformations, as postulated by Balandin in Russia. The volume and variety of types of catalytic reactions successfully accomplished by Russian chemists for the past quarter of a century is very extensive and, in many instances, are of a fundamental nature. As a relevant example may be mentioned the satisfactory solution of the difficult and important problem of the catalytic production of complex ethers directly from alcohols performed by Dolgoff[375] with his collaborators at the Leningrad Institute of High-pressure Reactions, the resultant process representing an original modification of the compound ether condensation reaction as evolved by Tischenko about 40 years ago.

Hydrocarbons

Butleroff laid the foundation to the comprehensive and profound studies of hydrocarbons in Russia. With his associate, Professor D. P. Konovaloff, he has investigated in detail the reaction of nitration of saturated hydrocarbons, which has attracted a great deal of attention in recent years. In Butleroff's works a prominent place occupy the syntheses and transformations of hydrocarbons of ethylene series, viz., the production of haloid derivatives (for example, ternary butyl chloride from isobutylene), hydration into alcohols, and the remarkable experiments on the polymerization of ethylene hydrocarbons as instanced by isobutylene (the derivation of di- and triisobutylene), thereby opening up a new important branch of organic chemistry of the polymerization of hydrocarbons.

Undoubtedly of vital interest are the classic works of Favorsky, commenced since 1884, on the isomerization of acetylene hydrocarbons into allene and di-vinyl (forms) structures and the reverse. His student, S. V. Lebediff, in his remarkable monograph on polymerization of diethylene hydrocarbons in 1912, has established a firm basis for his subsequent investigations (1928-1934), which gave Russia the largest synthetic rubber industry in the world.

Finally, it is worth while mentioning that cyclic (polymethylene) hydrocarbons from petroleum, termed by Markovnikoff the naphthenes and closely studied by him, together with his pupil Konovaloff (the nitrating reaction), have become the object of attention of Zelinsky, Demianoff, Nametkin and others.

The ethylene hydrocarbons have been for a long time the subject of intensive researches under the most diverse angles in Russia, where of late there have been developed the efficient industrial methods for passing from saturated hydrocarbons to ethylenes as well as to more unsaturated compounds by means of the catalytic dehydrogenation.[376]

(To be continued)

REFERENCES

(375) *Dolgoff and Co-workers; J. Gen. Chem., V,* 1688, 1935. **(376)** *Transactions Acad. Sc., U.S.S.R., No.* 1, 28, 1942.

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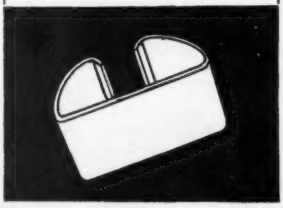

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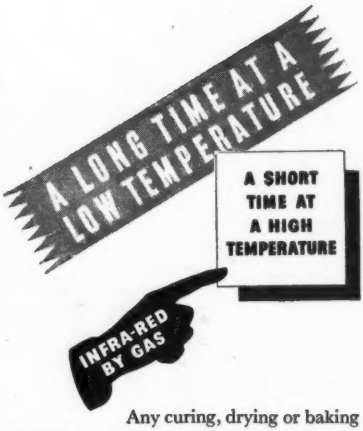

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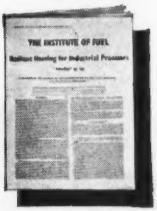

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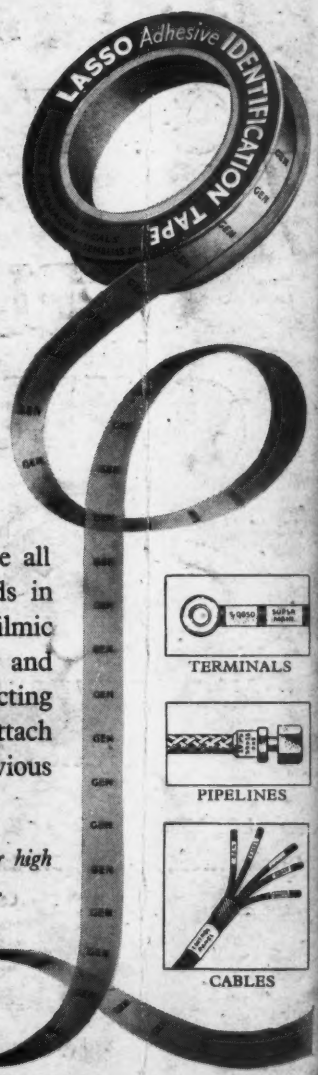

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